Part 1

Setting and Methodology

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ABBREVIATIONS AND ACRONYMS

AP	activity products
ARAR	applicable or appropriate and relevant requirement
ASTM	American Standard for Testing and Materials
As	arsenic
ATSDR	Agency for Toxic Substances and Disease Registry
AWQC	Ambient Water Quality Criteria
bgs	below ground surface
BHSS	Bunker Hill Superfund site
BigCrkSeg	Big Creek segment
BLM	Bureau of Land Management
BoM	U.S. Bureau of Mines
btoc	below top of casing
BURP	Beneficial Use Reconnaissance Project
BvrCrkSeg	Beaver Creek segment
°C	degree Celsius
CCSeg	Canyon Creek segment
Cd	cadmium
CDR	Coeur d'Alene River
CEC	cation exchange capacity
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFD	cumulative frequency distribution
CFR	Code of Federal Regulations
cfs	cubic foot per second
CIA	Central Impoundment Area
CLP	Contract Laboratory Program
cm	centimeter
Co	cobalt
COPC	chemical of potential concern
COPEC	chemical of potential ecological concern
CSM	conceptual site model
Cu	copper
CUA	common use area
DMEA	Defense Minerals Explorations Program
DO	dissolved oxygen
DOI	U.S. Department of Interior

ABBREVIATIONS AND ACRONYMS (Continued)

DQA	data quality assessment
DQO	data quality objective
DTM	digital terrain model
Ecology	Washington Department of Ecology
Eco RA	Ecological Risk Assessment
EE/CA	engineering evaluation and cost analysis
Eh	oxidation reduction potential
EPA	U.S. Environmental Protection Agency
°F	degrees Fahrenheit
FIA	Federal Insurance Administration
FIS	flood insurance study
FS	feasibility study
FSPA	field sampling plan addendum
g	gram
GIS	geographic information system
gpd	gallon per day
gpm	gallon per minute
GPR	ground penetrating radar
GPS	global positioning system
HHRA	human health risk assessment
HSI	habitat suitability index
Hz	hertz
I-90	Interstate 90
IDEQ	Idaho Department of Environmental Quality
lb	pound
LCDARB	Lower Coeur d'Alene River Basin
L/kg	liter per kilogram
LWD	large woody debris
m	meter
m^2	meter squared
m^3/s	cubic meters per second
main stem	main stem Coeur d'Alene River
meq	milliequivalent
MFG	McCulley, Frick & Gilman, Inc.
µg/dl	microgram per deciliter
µg/L	microgram per liter

ABBREVIATIONS AND ACRONYMS (Continued)

µm	micrometer
µS/cm	microsiemen per centimeter
mg/kg	milligram per kilogram
mg/L	milligram per liter
MidGradSeg	midgradient segment
mL/g	milliliter per gram
mol	mole
MoonCrkSeg	Moon Creek segment
MPN	most probable number
msl	mean sea level
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NFCDR	North Fork Coeur d'Alene River
Ni	nickel
NMSeg	Ninemile segment
North Fork	North Fork Coeur d'Alene River
NPDES	National Pollutant Discharge
NRDA	Natural Resource Damage Assessment
NTU	nephelometric turbidity unit
OM	organic matter
ORP	oxidation-reduction potential
Pb	lead
PCB	polychlorinated biphenyl
PDF	probability density function
PineCrkSeg	Pine Creek segment
ppb	parts per billion
pph	parts per hundred
ppm	parts per million
PrichCrkSeg	Prichard Creek segment
PVC	polyvinyl chloride
RAC	Remedial Action Contract
RAP	Regional Analytical Program
RBP	Rapid Bioassessment Protocol
RI	remedial investigation
ROD	Record of Decision
ROW	right of way
SBP	sub-bottom profiler

ABBREVIATIONS AND ACRONYMS (Continued)

SFCDR	South Fork Coeur d'Alene River
SFCDRSeg	South Fork Coeur d'Alene River Segment
SI	saturation index
South Fork	South Fork Coeur d'Alene River
SPT	standard penetration test
SRB	sulfate reducing bacteria
SRS	seismic reflection system
SVNRT	Silver Valley Natural Resource Trustees
SWOK	Southwest Labs of Broken Arrow, OK
SWRI	Southwest Research Institute
TDM	Technical Data Management
TDS	total dissolved solids
TSS	total suspended solids
UPPR	Union Pacific Railroad
URS	URS Corporation
URSG	URS Greiner, Inc.
URSGWC	URS Greiner Woodward Clyde
U.S.C.	United States Code
USCS	Unified Soil Classification System
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
USGS	U.S. Geological Survey
UTM	Universal Transverse Mercator
WQL	water quality limited
WWP	Washington Water Power [Company]
XRF	x-ray fluorescence
Zn	zinc

GLOSSARY OF TERMS

advective transport	The physical transport of water and associated concentrations from higher to lower hydraulic potential, exclusive of dispersion/mixing.
agriculture	The production of plants and animals useful to man, involving soil cultivation, the management of crops, and the breeding of livestock.
alluvium	Sediment deposited by flowing water, such as in a riverbed, floodplain, or delta.
applicable or relevant and appropriate requirements (ARAR)	Any standard requirements, criteria, or limitations under any state or federal statute that pertains to the release or potential release of a hazardous substance into the environment.
aquatic	Plants or animal life living in, growing in, or adapted to water.
assessment endpoint	In ecological risk assessment, an explicit expression of the environmental value to be protected; includes both an ecological entity and a specific attribute of that entity (e.g., salmon are a valued ecological entity; reproduction and population maintenance—the attribute—form an assessment endpoint).
background concentration	The concentration of a substance in environmental media that are not contaminated by the sources being assessed. Background concentrations are due to naturally occurring substances and other anthropogenic metals sources unrelated to mining (e.g., leaded gasoline emissions from cars).

GLOSSARY OF TERMS (Continued)

Beneficial Use Reconnaissance Project (BURP)	A program aimed at integrating biological and chemical monitoring with physical habitat assessment characterizing stream integrity and the quality of the water. This program was also developed in order to meet the Clean Water Act requirements of monitoring and assessing biology and developing biocriteria. This program relies heavily on protocols for monitoring physical habitat and macroinvertebrates developed by Idaho State University and DEQ in the early 1990s. It closely followed the Rapid Bioassessment Protocols for Use in Streams and Rivers: Benthic Macroinvertebrates and Fish developed by the EPA.
biota	All the plants and animals occurring within a certain area.
carcinogen	Any substance that can cause or contribute to the production of cancer.
chemicals of potential concern	Chemicals that are believed to be site-related contaminants and to pose potentially significant risk to endpoint receptors.
cleanup	Actions taken to deal with a release or the threat of a release of a hazardous substance that could affect humans and/or the environment. The term "cleanup" is sometimes used interchangeably with the terms "remedial action", "removal action", "response action", or "corrective action."
Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)	The 1980 federal law that authorized response actions for uncontrolled releases of hazardous substances to the environment (42 USC Section 9601 et seq.). CERCLA is commonly known as Superfund. The 1980 law was modified in 1986 by the Superfund Amendments and Reauthorization Act (SARA).

GLOSSARY OF TERMS (Continued)

conceptual model	A representation of the hypothesized causal relationship between the source of contamination and the responses of the endpoint entities. The conceptual site model for this final RI report describes contaminant releases, fate and transport, and effects of mining waste on humans and ecological receptors.
contaminant	A substance that is present in the environment due to release from an anthropogenic source and is believed to be potentially harmful.
contract laboratory program	A nationwide network of laboratories under contract to EPA that analyze soil, water, and waste samples taken from areas on or near Superfund sites. The laboratories in the program provide analytical data of known and documented quality for Superfund actions.
cumulative distribution function (CDF)	Cumulative distribution functions are graphic presentations used for describing the likelihood that a variable will fall within different portions of an overall range of values.
cumulative frequency distribution	Any listing of scores, observations, or data according to ordered classes in which the total number of entries in each class contains all those cases falling in lower classes. The last class thus includes all of the data from the distribution.
data quality assessment (DQA)	A statistical and scientific evaluation of the data set to determine the validity and performance of the data collection design and statistical test and to determine the adequacy of the data set for its intended use.

GLOSSARY OF TERMS (Continued)

data quality objectives (DQO)	Qualitative and quantitative statements of the overall level of uncertainty that a decision-maker will accept in results or decisions based on environmental data. They provide the statistical framework for planning and managing environmental data operations consistent with user's needs.
digital terrain model	A representation of a surface's topography stored in a numerical format. Each pixel has been assigned coordinates and an altitude.
dike	An embankment or ridge of either natural or man-made materials used to prevent the movement of liquids, sludges, solids, or other materials.
dissolved	Those materials in water or other liquids that pass through a 0.45 μm membrane filter.
ecological receptors	Aquatic and terrestrial plants and animals most likely to be impacted by the chemicals of potential concern.
ecosystem	The functional system consisting of the biotic community and abiotic environment occupying a specified location in space and time.
epilimnion	Upper waters of a thermally stratified lake.

GLOSSARY OF TERMS (Continued)

euphotic	The topmost layer of a lake or sea in which there is sufficient light for net primary production, i.e. where the energy fixed by photosynthesis exceeds that lost by respiration. The depth varies, depending on such factors as turbidity, supply of nutrients in the water, tidal turbulence, and temperature. For example, high nutrient levels will encourage a greater biomass of phytoplankton near the surface, which causes shading and consequent reduction in depth of the euphotic zone. It typically ranges from <1 m to about 30 m in lakes and coastal waters, and rarely reaches depths of more than 200 m in the open ocean.
eutrophic	Nutrient-rich waters characterized by abundant plant growth and frequent algal blooms.
exposure	The contact or co-occurrence of a contaminant or other agent with a receptor.
exposure pathway	The physical route by which a contaminant moves from a source to a biological receptor. A pathway may involve exchange among multiple media and may include transformation of the contaminant.
exposure point concentration (EPC)	A concentration to which receptors would most likely be exposed.
exposure route	The means by which a contaminant enters an organism (e.g., inhalation, ingestion).
ex situ	Pertaining to the study or maintenance of an organism or groups of organisms away from the place where they naturally occur. Commonly associated with collections of plants and animals in storage facilities, botanic gardens, or zoos.

GLOSSARY OF TERMS (Continued)

feasibility study (FS)	The development and analysis of the potential cleanup alternatives for a site on the state registry [National Priorities List]. The feasibility study usually starts as soon as the remedial investigation is underway; together, they are commonly referred to as the "RI/FS."
gangue	The nonmetalliferous or nonvaluable metalliferous minerals in an ore.
geographic information systems (GIS)	Software that uses spatial data to generate maps or to model processes in space; commonly abbreviated as GIS.
geomorphology	The study of the classification, description, nature, origin, and development of present landforms and their relationships to underlying structures, and of the history of geologic changes as recorded by these surface features.
global positioning system (GPS)	A satellite navigational system controlled by the U.S. Department of Defense. Hand-held GPS receivers process signals from a minimum of four satellites to compute accurate measurements of latitude, longitude, velocity, and time.
ground penetrating radar	A geophysical method that uses high-frequency, electromagnetic waves to obtain subsurface information. The waves are radiated into the subsurface by an emitting antenna. When a wave strikes a suitable object, a portion of the wave is reflected back to the receiving antenna.
groundwater	The supply of fresh water found beneath the earth's surface, usually in aquifers, which supplies wells and springs. Because ground water is a major source of drinking water, there is growing concern over contamination from leaching agricultural or industrial pollutants or leaking underground storage tanks.

GLOSSARY OF TERMS (Continued)

hazardous substance	Any element, compound, mixture, solution, or substance designated pursuant to the Superfund law (Section 101(14) of CERCLA); examples include lead, zinc, and cadmium.
hazardous waste	By-products of society that can pose a substantial or potential hazard to human health or the environment when improperly managed. To be declared hazardous, waste must (a) possess at least one of four characteristics: ignitability, corrosivity, reactivity, and toxicity, or (b) appear on special environmental caution lists (Section 261.3 of RCRA).
hydrology	The science dealing with the properties, distribution, and circulation of water.
hypolimnion	The lowest layer in a thermally stratified lake or reservoir. This layer consists of colder, more dense water, has a constant temperature, and no mixing occurs.
in situ	In place, the original location, in the natural environment.
institutional controls	Institutional controls are legal mechanisms designed to control exposures to chemicals in environmental media, including soil and groundwater. These controls are usually part of a facility's cleanup program where contamination remaining in place causes the use of the property to be restricted.
lacustrine	Includes wetlands and deepwater habitats that occur in depressions (such as the lateral lakes and Coeur d'Alene Lake) or dammed river channels (such as Long Lake).
media	Specific environments—air, water, soil—which are the subject of regulatory concern and activities (singular:

GLOSSARY OF TERMS (Continued)

	medium).
micrograms per liter (µg/L)	Unit used to measure contaminants in water. This measurement is equivalent to parts per billion (ppb). A µg/L is one thousand times less than a mg/L (part per million). To convert µg/L to mg/L (ppb to ppm), divide by 1,000.
milligrams per kilogram (mg/kg)	Unit used to measure contaminants in soil (equivalent to parts per million). A mg/kg is one thousand times greater than a µg/kg (part per billion). To convert mg/kg to µg/kg (ppm to ppb), multiply by 1,000.
monitoring well	A well drilled at a hazardous waste management facility or Superfund site to collect ground-water samples to determine the amounts, types, and distribution of contaminants in the groundwater beneath the site by physical, chemical, or biological analysis.
morphology	The study of the form of lands.
National Oil and Hazardous Substances Pollution Contingency Plan (NCP)	The NCP contains the regulations that implement the CERCLA response process. The NCP also provides information about the roles and responsibilities of the EPA, other federal agencies, states, and private parties regarding releases of hazardous substances.
National Pollutant Discharge And Elimination System (NPDES)	A provision of the Clean Water Act which prohibits discharge of pollutants into waters of the United States unless a special permit is issued by the EPA, a state, or, where delegated, a tribal government on an Indian reservation.

GLOSSARY OF TERMS (Continued)

National Priorities List (NPL)	The EPA's list of the most serious uncontrolled or abandoned hazardous waste sites identified for possible long-term remedial action under Superfund. The list is based primarily on the score a site receives from the hazard ranking system. The EPA is required to update the NPL at least once a year. A site must be on the NPL to receive money from the Trust Fund for remedial action.
Natural Resource Damage Assessment (NRDA)	The legal and technical process to pursue restoration for injuries to natural resources caused by discharges of oil and releases of hazardous materials into the environment.
oligotrophic	Nutrient-poor waters with low plant productivity and high transparency.
organic compound	Naturally occurring animal- or plant-produced (or synthetic) substances containing mainly carbon, hydrogen, nitrogen, and oxygen.
organic matter	Carbonaceous waste contained in plant or animal matter and originating from domestic or industrial sources.
palustrine	Wetland habitats that are dominated by trees, shrubs, and other persistent, emergent wetland plants.
preliminary remedial goal (PRG)	A contaminant concentration, toxic response, or other criterion identified from the risk assessment that is provided to risk managers to assist in making decisions for remedial action (see also *remedial goal*).

GLOSSARY OF TERMS (Continued)

probability density function	The mathematical function which allocates probabilities of particular observations occurring. The probability density function may be used to construct a frequency distribution of certain events occurring either discretely, in the form of a histogram, or continuously.
quality assurance (QA)/ quality control (QC)	A system of procedures, checks, audits, and corrective actions to ensure that all EPA research design and performance, environmental monitoring and sampling, and other technical and reporting activities are of the highest achievable quality.
rapid bioassessment protocol	A protocol designed to provide basic aquatic life data for water quality management purposes such as problem screening, site ranking, and trend monitoring (see Beneficial Use Reconnaissance Project (BURP)).
receptor	An organism, population or community that is exposed to contaminants. Receptors may or may not be assessment endpoint entities.
record of decision (ROD)	A public document that explains which cleanup alternative(s) are selected.
recovery	The return of a population, community, or ecosystem process to a previous, valued state. Due to the complex and dynamic nature of ecological systems, the attributes of a "recovered" system must be carefully defined.
release	Any spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing into the environment of a hazardous or toxic chemical or hazardous substance.

GLOSSARY OF TERMS (Continued)

remedial action objective	A specification of contaminants and media of concern, potential exposure pathways, and cleanup criteria (see remedial goal).
remedial goal	A contaminant concentration, toxic response, or other criterion that is selected by the risk manager to define the condition to be achieved by remedial actions.
remedial investigation	An in-depth study designed to gather the data necessary to determine the nature and extent of contamination at a site; establish criteria for cleaning up the site; identify preliminary alternatives for remedial actions; and support the technical and cost analyses of the alternatives. The remedial investigation is usually done with the feasibility study. Together they are usually referred to as the "RI/FS."
remediation	Cleanup or other methods used to remove or contain a toxic spill or hazardous materials from a Superfund site. Remediation is the goal of the CERCLA RI/FS process.
riparian	Occurring in or by the edge of a stream (including its floodplain) or a lake.
risk assessment	A qualitative or quantitative evaluation of the environmental and/or health risk resulting from exposure to a chemical or physical agent (pollutant); combines exposure assessment results with toxicity assessment results to estimate risk.
riverine	The habitat within streams.
saturation index	The condition of a liquid when it has taken into solution the maximum possible quantity of a given substance at a given temperature and pressure.

GLOSSARY OF TERMS (Continued)

sediment	Loose particles of sand, clay, silt, and other substances that settle at the bottom of a body of water. Sediment can come from the erosion of soil or from the decomposition of plants and animals. Wind, water, and ice often carry these particles great distances.
sill	An intrusion of igneous rock which spreads along bedding planes in a nearly horizontal sheet. This level sheet may be up to 300 m in thickness.
soil	Complex mixture of inorganic minerals (i.e., mostly clay, silt, and sand), decaying organic matter, water, air, and living organisms.
source	An entity or action that releases contaminants or other agents into the environment (primary source) or a contaminated medium that releases the contaminants into other media (secondary source). Examples of primary sources for contaminated sites include spills, leaking tanks, dumps, and waste lagoons.
stakeholders	Individuals or organizations that have an interest in the outcome of a response action but are not official parties to the decision making. Examples include natural resource agencies and citizens groups. A somewhat clearer synonym is "interested parties."
superfund	The program operated under the legislative authority of CERCLA and SARA that funds and carries out EPA solid waste emergency and long-term removal and remedial activities. These activities include establishing the National Priorities List, investigating sites for inclusion on the list, determining their priority, and conduct and/or supervising cleanup and other remedial actions.

GLOSSARY OF TERMS (Continued)

Superfund Amendments and Reauthorization Act of 1986 (SARA)	Reauthorization and modifications to CERCLA enacted on October 17, 1986.
surface water	All water naturally open to the atmosphere (rivers, lakes, reservoirs, ponds, streams, impoundments, seas, estuaries, etc.).
tailings	Rock and other waste materials removed as impurities when minerals are mined and mineral deposits are processed. These materials are usually dumped on the ground or into ponds.
terrestrial	Plants or animals living in upland ecosystems not associated with water.
toxicity	The degree to which a substance or mixture of substances can harm humans or animals. Acute toxicity involves harmful effects in an organism through a single or short-term exposure. Chronic toxicity is the ability of a substance or mixture of substances to cause harmful effects over an extended period, usually upon repeated or continuous exposure sometimes lasting for the entire life of the exposed organism. Subchronic toxicity is the ability of the substance to cause effects for more than one year but less than the lifetime of the exposed organism.
transmissivity	The rate at which water of the prevailing kinematic viscosity is transmitted through a unit width of the aquifer under a unit hydraulic gradient.

GLOSSARY OF TERMS (Continued)

U.S. Environmental Protection Agency (EPA)	The EPA is the U.S. Government's principal agency responsible for controlling the pollution of air and water, pesticides, radiation hazards, and noise pollution. The agency is also involved in research to examine the effects of pollution.
weight of evidence	A type of analysis that considers all available evidence and reaches a conclusion based on the amount and quality of evidence supporting each alternative conclusion, or the result of a weight-of-evidence analysis.
wetland	An area that has a combination of soil characteristics (referred to as "hydric" soils), vegetation (such as cattails or sedges), and periods of inundation by water that facilitates habitat for aquatic organisms and/or water-related wildlife.
x-ray fluorescence (XRF)	A method of testing for metals in which a sample is irradiated with a beam of x-rays.

1.0 INTRODUCTION

The Coeur d'Alene Mining District is located within the Coeur d'Alene River basin in the eastern portion of the panhandle of northern Idaho. The district has been one of the leading producers of lead, silver, and zinc in the United States. Mining activities in the district began more than 100 years ago.

Past mining, milling, refining, and smelting practices have resulted in significant areas within the Coeur d'Alene River basin being contaminated by hazardous substances. The contamination resulted from the discharge or erosion of mill tailings, and other mine-generated waste into the South Fork Coeur d'Alene River (South Fork), or into tributaries connected to the South Fork. These mill tailings contained metals, such as arsenic, cadmium, lead, and zinc. Exposures to high concentrations of such metals have been associated with adverse impacts to human health and the environment. The principal human health concerns are associated with lead and its potential to cause neurological developmental effects in children; and arsenic for its potential to cause cancers and various pre-cancer and noncancer effects in skin by ingestion. The principal ecological concerns are associated with cadmium, lead and zinc, which present significant ecological risks to most ecological receptors, both aquatic and terrestrial, throughout the basin.

In 1998, the U.S. Environmental Protection Agency (EPA) initiated a remedial investigation/feasibility study (RI/FS) of mining-related contamination in the Coeur d'Alene basin. The study excluded parts of an area known as the Bunker Hill Superfund Site, which were previously investigated by EPA. This report presents the results of the remedial investigation of the Coeur d'Alene basin. The basin, as evaluated in the remedial investigation, includes the watershed and floodplains of the South Fork and main stem of the Coeur d'Alene River, Coeur d'Alene Lake, and the Spokane River that drains from Coeur d'Alene Lake and crosses from Idaho into Washington state.

Within this geographic scope are residential communities, recreational areas, active and inactive mining facilities, the Bunker Hill Superfund Site, parts of the Coeur d'Alene Indian Reservation, parts of Kootenai, Benewah and Shoshone counties of northern Idaho and parts of Stevens, Lincoln and Spokane counties in western Washington. The Spokane Indian Reservation borders the north side of the Spokane River.

1.1 PURPOSE OF REPORT

This report summarizes data and analyses on the nature and extent of mining contamination in the basin. Data have been collected and analyses conducted through the RI/FS process of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 U.S.C. 9601 et seq., and the implementing regulations in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 CFR Part 300. The information presented in this RI report will be used to evaluate risks to human health and the environment and potential remedial alternatives.

In the view of EPA and the United States, the geographic area evaluated in this RI/FS is included in the Bunker Hill Mining and Metallurgical complex facility that was added to the National Priorities List (NPL) in 1983. In September 1998, a federal district court judge ruled that this NPL facility was limited to the 21-square-mile area known as the Bunker Hill Superfund Site (*U.S. v. ASARCO Inc.*, 28 F. Supp.2d 1170). This ruling was vacated on appeal by the Ninth Circuit Court of Appeals 214 F.3d 1104. This leaves standing the view of EPA and the United States. Inclusion on the NPL is not a precondition for the conduct of an RI/FS, pursuant to Section 104(b)(1) of CERCLA, 42 U.S.C. 1 9604(b)(1). See also NCP 40 CFR Part 300.425(b)(1).

The current RI/FS for the Coeur d'Alene basin followed upon earlier efforts to characterize the nature and extent of mining contamination within the basin. Within the area of the basin known as the Bunker Hill Superfund Site (BHSS), RI/FS activities have already been completed, resulting in CERCLA Records of Decision (RODs) in 1991 and 1992. Remedial actions under the two BHSS RODs are currently being implemented, largely addressing areas impacted by smelter operations. Actions under the 1992 ROD are expected to reduce the discharge of mining contaminants into the South Fork as it flows through the BHSS. However, to meet water quality objectives for the South Fork, the 1992 ROD explicitly recognized that actions within the basin beyond the BHSS would be needed.

Broader threats from mining contamination in the basin were indicated prior to issuance of the first two BHSS RODs. These threats include risks to human health within residential communities and recreational areas outside the BHSS. These threats also include impacts on ecological receptors outside the BHSS, such as fish and waterfowl. To evaluate these threats in a comprehensive manner, EPA began this RI/FS for the Coeur d'Alene basin in early 1998. EPA has contracted with URS Greiner, Inc., and CH2M HILL to conduct this RI/FS, in partnership with the Coeur d'Alene Tribe, State of Idaho, State of Washington, and other federal, state, tribal, and local agencies.

To ensure opportunities for stakeholder involvement, EPA has prepared a Community Involvement Plan (USEPA, 1999), established an Administrative Record file and local information repositories, conducted or participated in dozens of public meetings and interviews in local communities, prepared and distributed fact sheets, and circulated for public review draft documents such as numerous field sampling plans and the technical work plan for the Bunker Hill Basin-Wide RI/FS (USEPA 1998).

1.2 SITE BACKGROUND

1.2.1 Site Description

The Coeur d'Alene basin encompasses a large, diverse geographic area. The basin, as evaluated in the remedial investigation, includes the Coeur d'Alene River and associated tributaries (including portions that run through the BHSS), Coeur d'Alene Lake, and the Spokane River downstream to the Washington State Highway 25 bridge at Fort Spokane on the Spokane Arm of Lake Roosevelt. From east to west, the major surface water features in the basin are the South Fork, North Fork and main stem of the Coeur d'Alene River, lateral lakes and wetlands associated with the main stem of the Coeur d'Alene River, Coeur d'Alene Lake, the Spokane River, Long Lake, and the Spokane Arm of Lake Roosevelt. Towns in the basin include (from east to west) Mullan, Wallace, Osburn, Kellogg, Kingston, Harrison, Coeur d'Alene, and Post Falls. Farther west along the Spokane River is the city of Spokane. Major roadways in the basin are Interstate 90, Highway 95, and Highway 3. Dams along the Spokane River associated with hydroelectric projects include Post Falls, Upper Falls, Monroe Street, Ninemile Falls, Long Lake, and Little Falls.

The Coeur d'Alene basin serves as a drainage for numerous smaller watersheds on the western slope of the Bitterroot Mountains (Figures 1.2-1 and 1.2-2). The basin originates near the Idaho-Montana border and extends westward, draining approximately 1,475 square miles of area upstream of Coeur d'Alene Lake (Beckwith et al. 1997).

The South and North Forks are rocky, high-gradient streams in narrow valleys confined by steep hillsides (Beckwith et al. 1997; Ridolfi 1998). The two forks come together near Enaville to form the main stem. The South Fork drains several smaller watersheds including Big Creek, Canyon Creek, Moon Creek, Ninemile Creek, and Pine Creek. The North Fork receives drainage from Beaver Creek and Prichard Creek.

The main stem is a fine-substrate, low-gradient meandering river in a broad valley. The valley includes vast floodplains, 12 shallow lateral lakes, and thousands of acres of wetlands, all of which are hydraulically connected with the main stem Coeur d'Alene River, which flows into Coeur d'Alene Lake near Harrison. Coeur d'Alene Lake encompasses 50 square miles and includes Wolf Lodge Bay, an arm of the Lake at the northern end. Coeur d'Alene Lake discharges through the Spokane River, which is a tributary of the Columbia River. The Spokane River is dammed in six locations (described later) upstream of the Spokane Arm of Lake Roosevelt, which is created by the Grand Coulee Dam on the Columbia River.

Within the basin, the Coeur d'Alene mining district is located east of the confluence of the South and North Forks. The principal mines are concentrated along approximately 35 miles of the South Fork and 15 miles of the North Fork and their tributaries (USEPA 1991). Mining in these areas generated waste rock and mill tailings that contaminated the hillsides, floodplains, streams, and rivers. The mining activity acted to increase the exposure and weathering of mineralized rock and tailings. Over time, natural processes have continued to transport large volumes of metal contamination down the river system and deposit it in the beds and banks of the main stem, floodplains, the lateral lakes, Coeur d'Alene Lake, and the Spokane River. A detailed physical description of the study area is included in Section 3.

1.2.2 Site History

The mining history of the Coeur d'Alene basin began with the discovery of placer gold deposits in 1883 on Prichard Creek, a tributary of the North Fork. News of the gold strike attracted a rush of miners to the region. By 1884, lead-silver lode deposits (including the Polaris, the Tiger-Poorman and the Morning) were discovered in tributaries of the South Fork. Soon after, mines, mills, and towns began to alter the landscape of the basin. The U.S. Bureau of Land Management has identified approximately 1,080 mining or milling features within the basin that are a result of mining activity within the district (BLM 1999). Over the years, improvements have been made in mining technologies, transportation, concentration techniques, and the handling of waste products from mining activities, all of which have affected the Coeur d'Alene basin and its inhabitants. From excavation of the district's first mines in the late 1800s to the present, the Coeur d'Alene mining district has been one of the leading producers of lead, zinc, and silver ore in the United States. Gold, antimony, tungsten, and copper have also been mined in the Coeur d'Alene basin. Described below are mining practices noted by Stratus (2000):

> Much of the ore produced in the basin required concentration before smelting. The first mill in the basin, associated with the Bunker Hill mine, began operations in 1886 (Casner 1991). Between 1886 and 1997, at least 44 mills are known to have operated along the

South Fork of Coeur d'Alene River. Initially, ores were concentrated by pulverization and gravity separation. Pulverized material was mixed with water and agitated or "jigged." This separated the heavier ores from the lighter host rock. The valuable ores were collected as concentrates, and the waste material, or jig tailings, was sluiced to dumps or to nearby flowing surface water. Gravity separation was an inefficient recovery process, and jig tailings contained as much as 10% lead or zinc (Long 1998). Some small operators established operations to reprocess these tailings deposits and extract more lead, zinc, and silver (Quivik, 1999). However, until new technologies such as flotation made the jig tailings profitable sources of mineral wealth, it was more profitable for larger operations to work fresh ore than re-work tailings (Quivik, 1999).

In 1912, flotation milling was introduced to the basin (Casner 1991). Flotation milling involved finer pulverization of ores and mixing with water and an oil or grease flotation material. When the mixture was agitated and aerated, metal sulfides adhered to the froth on top and were drawn off as concentrates. The host material settled and was sluiced as tailings to dumps or to nearby flowing surface water. Flotation milling greatly enhanced the efficiency of recovery of minerals, so the remaining tailings had lower concentrations of valuable minerals than did jig tailings. This advancement in technology made it profitable to reprocess old tailings, and companies began re-treating many of the tailings deposited in creeks, dumps, and impoundments in the Coeur d'Alene mining region.

The waste material from the mills contained sulfide and oxide compounds of antimony, bismuth, cadmium, copper, gold, lead, iron, silver, and zinc. The oxide and sulfide forms (when weathered) are leachable and subject to mobilization (MFG 1992).

Since milling required large volumes of water, the mills were constructed near sources of surface water. Many were located in steep narrow canyons with little area available for tailings disposal, so tailings were discharged to the streams or sluiced to the South Fork Coeur d'Alene River (Fahey 1990). Mills along the South Fork Coeur d'Alene River discharged most processing wastes (milling) directly to the river. Tailings dumped in the floodplain often subsequently eroded to the stream (Casner 1991). For over 80 years, from 1886, when milling began in the basin until 1968, when mills were required to impound tailings, the predominant tailings disposal method upstream of Elizabeth Park was discharge to nearby streams (Fahey 1990; Long 1998). Downstream of Elizabeth Park, tailings were deposited in the current locations of the Central Impoundment Area (CIA) and Page Pond beginning in 1926 (MFG 1992).

Tailings have been mixed with alluvium and redistributed throughout the Coeur d'Alene basin (MFG 1992). Jig tailings, which were sand-sized particles, settled rapidly on the banks of the creeks in which they were deposited. Seasonal high flows flushed the jig tailings downstream. Flotation tailings had a fine, silty texture. Tailings were transported downstream and deposited on the floodplains, banks, and beds of the South Fork and lower Coeur d'Alene rivers (MFG 1992). In 1903, the first of a series of pollution damage suits was filed by a Shoshone County farmer (Casner 1991). By the mid-1920s, a visible tailings plume had extended the length of the Coeur d'Alene River, across Coeur d'Alene Lake, and as far as the Spokane River (Casner 1991).

Estimates of the volume of tailings discharged to the South Fork Coeur d'Alene River and its tributaries range from 54.5 to more than 70 million tons, depending on the source (Long 1998; Mine Systems Design Inc., as cited in Shoshone Natural Resources Coalition 2000; MFG 1992). A 1998 estimate of 61.9 million tons developed by the USGS (Long 1998) is believed to be the most accurate and falls near the midpoint of the range of estimates.

A railroad line was constructed in the late 1800s to serve the mining industry in the Silver Valley, transporting ores and concentrates to and from the mines and processing facilities in the area. Approximately 80 percent of the 71.5 mile right of way (ROW) for the railroad main line and sidings of the Wallace-Mullan Branch generally follows the Coeur d'Alene River and is mostly within the floodplain. The remaining 20 percent is adjacent to Coeur d'Alene Lake or in the upland areas of the Coeur d'Alene Reservation. In many locations, the line was constructed on top of a pre-existing mantle of fluvially deposited tailings, and used tailings and waste rock in portions of the line as construction material (MFG 1999). Approximately 168,000 cubic yards of ballast were placed originally, comprised of a mixture of tailings, waste rock, and locally available gravels, most of which is still in place. At sidings and loading and unloading areas, there is evidence of occasional spillage, resulting in further elevated lead concentrations. The ROW was the subject of an Engineering Evaluation/Cost Estimate (MFG 1999) which was conducted in accordance with the EPA's Guidance on Conducting Non-Time-Critical Removal Actions Under CERCLA.

The quantities of tailings discharged to the Coeur d'Alene basin constitutes a substantial amount of material. It is estimated that approximately 62 million tons of tailings were discharged to the Coeur d'Alene basin. Assuming that 1 cubic foot of tailings weighs approximately 125 pounds, if all the tailings discharged to the river were piled on a football field (approximately 100 yards by 50 yards), the pile would reach more than 4 miles high. Recognizing that the mining waste discharged to the river has been commingled with clean sediment, which then itself becomes contaminated, the total amount of contaminated material in the basin is significantly greater than 62 million tons.

During the 1940s and early 1950s, some jig tailings deposits in the basin were remilled, mainly for their high zinc content. While this effort removed additional metals from the jig tailings, it also resulted in the production and discharge of additional flotation tailings. Although these tailings contained less zinc than the jig tailings, their finer grain size allowed more rapid dispersion of the remaining zinc into the environment.

In the late 1960s impoundment of tailings became the standard practice and subsequent direct discharge of tailings to streams have been limited mainly to lateral erosion of historic tailings piles and redistribution of existing tailings. Tailings impoundments continue to release metals-contaminated water to surface water and groundwater, but in response to requirements of the Clean Water Act, discharges to surface waters from permitted impoundments have been greatly reduced over time. The RI/FS for the Bunker Hill Superfund Site has resulted in two CERCLA Records of Decision (RODs) and associated remedial activities. These ongoing remedial activities are expected to reduce discharges of mining wastes to the South Fork as it flows through the Superfund site. In addition, remedial actions have been implemented by the mining companies, the U.S. Bureau of Land Management, and the U.S. Forest Service at some locations on the South Fork and tributaries. Those actions are also expected to reduce releases of metals over time.

1.2.3 Previous Investigations

Numerous studies to determine the extent of contamination and its potential impacts have been conducted by the mining companies, resource trustees, and others. Specific historical studies and data sets were selected for inclusion in this remedial investigation report, based on their representativeness of current site conditions. Additionally, URS Greiner, Inc., CH2M HILL, and the U.S. Geological Survey (USGS) collected soil, sediment, groundwater, and surface water samples on behalf of the EPA beginning in 1997. Data included in this report are discussed in Section 4. Data were collected for this study to define and delineate areas that could be targeted for remediation based on a combination of factors including source of environmental impacts. This report focuses on determining which source areas are contributing the majority of contamination to the environment.

1.2.4 Cleanup Actions to Date

Numerous cleanup actions have been implemented in the basin. Specific actions for each watershed are described in this section. Actions were generally taken at locations where time-critical removal or stabilization of a source was deemed necessary and not as part of a comprehensive plan for basin remediation. The collective actions described below are not sufficient to be protective of human health and the environment for the basin.

1.2.4.1 Beaver Creek

Previous clean-up action in the Beaver Creek watershed consists of some isolated portal closures conducted by the USDA Forest Service in the 1998, 1999 and 2000 field seasons. This watershed is included in an integrated watershed analysis of the Prichard, Beaver and Eagle Creek drainages that is currently being performed for the Forest Service and Bureau of Land Management by the United States Geological Survey. The watershed analysis is being used to help assess the environmental and human health risks, and to establish priorities for reclamation work at numerous abandoned mine sites located in the National Forest lands in these watersheds (Johnson, 2000).

1.2.4.2 Big Creek

There have been no known major cleanup activities in the Big Creek watershed. During the 2000 field season, the USDA-Forest Service performed some minor grading to stabilize an access road around the waste rock dump at the Idaho-Leadville mine site; they have also performed several isolated portal closures (Johnson, 2000).

1.2.4.3 Canyon Creek

There have been several previous clean-up activities in the Canyon Creek watershed. During the 1997 and 1998 field seasons, the Silver Valley Natural Resources Trustees performed several removal actions for the Frisco and Gem mill sites, the Standard Mammoth Facility, the Black Bear Fraction and Flynn Mines and the Canyon Silver (Formosa) mine and mill sites. In addition, contaminated tailings and sediment were also removed from the Canyon Creek channel and impacted riparian zone from the Gem mill site downstream to Woodland Park. Soils at removal areas were amended with organic materials and revegetated; the stream was stabilized using bioengineering methods (Harvey, 2000). With the exception of grasses in some areas, attempts to establish other vegetation (trees and shrubs) were not successful. An unlined repository was constructed at Woodland Park to contain the estimated 600,000 cubic yards of material yielded by these removals. This repository was capped with growth media and revegetated (Harvey, 2000). Recent monitoring by USGS indicates a plume of metals contaminated groundwater down-gradient from this repository (Box, 1999).

One of the Mining Companies is presently installing a passive-treatment pilot on top of the Star Tailings Pond. In the 2000 field season, a 1.25-mile long, 8-inch diameter pipeline from the Gem Portal to the Star Pond was installed. The 10 gallon-per-minute pilot is designed to treat a portion of the Gem discharge using two parallel treatment trains: one with a vertical filtration cell and high permeability bioreactor, and the other with vertical filtration and low permeability bioreactor. The pilot will be used to help assess the effectiveness of these methods in effectively treating acid mine drainage. Implementation is expected to occur in the 2001 field season (Hansen, 2000).

Several actions have also been implemented to address human health concerns in this watershed. During the 1997, 1998, and 1999 field seasons, the USACE on behalf of the EPA has performed several residential soil cleanups determined to be necessary to protect human health. These actions include removals at 10 residential properties within the Canyon Creek watershed. In addition, one home was placed on an end-of-tap water purification system, as their water did not meet the Removal Action Level for drinking water (USEPA, 1999, USEPA 2000a and 2000b).

1.2.4.4 Moon Creek

During the 1998, 1999 and 2000 field seasons, the USDA Forest Service implemented the East Fork Moon Creek Reclamation Project as a CERCLA non-time critical removal project to address the Charles Dickens and Silver Crescent mine and mill sites. The project entailed removing 130,000 cubic yards of jig and flotation tailings, waste rock, and contaminated soil with placement in an unlined combined waste repository onsite. The repository base includes a limestone drain system with impervious berm to address groundwater. The cover is an engineered multi-layer capillary-break type cap containing a geosynthetic clay liner. This project also included closing and sealing four adits and two mine shafts. While the drainage from the Silver Crescent adit had sample results that indicated neutral pH and low metals, a wetlands buffer was installed to intercept this drainage. In addition, the project included over 3,300 feet of channel rehabilitation, floodplain re-construction and nearly 10 acres of revegetation by seeding and planting methods (REI, 2000 and Johnson, 2000).

1.2.4.5 Ninemile Creek

In the Ninemile Creek watershed, previous cleanup actions have been implemented to address the Interstate Callahan mine and mill, the Success mine sites, and a portion of the impacted channel and riparian zone for the east fork and main stem of the channel. In addition, several actions have also been implemented to address human health concerns. In the 1992 and 1993 field seasons, the Mine Operator graded the mine waste rock pile and tailings at the Interstate-Callahan site to remove it from the floodplain (CDARPT, 1994). This action was followed in 1998 by a non-time critical removal of 66,000 cubic yards of waste rock and tailings and placement in an unlined repository onsite. This repository had a rock pad to allow groundwater through-flow, and a multi-layered cap with a bentonite-augmented soil barrier layer. The cap was revegetated and armored on the sides for erosion control (USEPA, 1998, Golder, 1998 and Calibretta, 1998).

In 1993, EPA implemented time-critical removal actions at the Success mine and mill site. This action included re-locating about 1,600 feet of the east fork of Ninemile Creek channel, regrading the waste rock pile away from the channel, placement of grade control and energy dissipation structures into the channel, and capping the tailings with a one-foot thick layer of rock (USEPA, 1993). Concurrent with the actions by EPA, IDEQ installed upgradient surface water drainage and ground water interceptor drains to collect groundwater and drainage from the Alameda and Success adits. This drainage was directed to infiltration galleries along the edges of the waste rock pile (Harvey, 2000). In 1998, a bench-scale pilot project was undertaken by IDEQ to evaluate in-situ passive treatment processes to treat groundwater at the Success mine site (Terragraphics, 1998). As a result of the bench scale testing, in late 2000, IDEQ began implementing a pilot project to test the effectiveness of a permeable reactive barrier using apatite as the treatment media to address groundwater from the Success site (Golder, 2000). Under IDEQ guidance, work is continuing on the installation of a full-scale cutoff wall.

During the 1994 field season, the Silver Valley Natural Resource Trustees (SVNRT) along with the IDEQ and Hecla, performed time-critical removals in the lower 0.5-mile segment of the east fork of Ninemile Creek, and a 0.75 mile stretch of the main stem of Ninemile Creek near Black Cloud. These actions included removal of contaminated tailings, waste rock and sediment based upon visual identification, followed by riparian stabilization and revegetation. Approximately 150,000 cubic yards of material were placed in a repository on top of the existing Day Rock tailings impoundment and were capped with native soils and growth media (CDARPT, 1994). In 1998, the fish pond located near the confluence of the east and west forks of Nine Mile Creek was re-constructed as off-channel habitat (Calibretta, 1998).

During the 1998 and 1999 field seasons, the USACE on behalf of the EPA performed a residential soil cleanup and placed one home on an end-of-tap water purification system determined to be necessary to protect human health for these residents (USEPA 1999, and 2000a).

1.2.4.6 Pine Creek

Several time-critical and non-time critical clean-up responses have been implemented by the Bureau of Land Management on public lands in the Pine Creek watershed. In the 1996 and 1997 field seasons under a time-critical removal, two tailings ponds associated with the Douglas mine and mill site were removed from the east fork of Pine Creek (USEPA, 1996). Approximately 25,000 cubic yards of materials were removed and placed into a temporary repository near the mine (Fortier, 2000). Following the flooding in 1996 and 1997, funding by the Federal Emergency Management Agency was used to conduct time-critical removals of approximately 23,000 cubic yards of contaminated soils and tailings from the Amy-Matchless, the Liberal King, and a portion of the Denver Creek tailings piles (BLM, 1998). These materials were initially removed to a Temporary Storage area at the Upper Constitution Mill site, and then in 1998, were relocated from the Temporary Storage Area to the Central Impoundment Area (CIA) within the Bunker Hill Site.

Following these time-critical removals, additional non-time critical removals were performed in 1998 at the Amy Matchless site, and at the Liberal King Site. About 2,200 cubic yards of tailings were removed to the CIA as a part of this action. These areas were then re-graded, soil media was imported, and the disturbed areas at these sites were re-vegetated. BLM plans additional actions to cleanup the mill site in 2000, along with a pilot treatment system for the adit drainage (Fortier, 2000).

In the 1998 and 1999 field seasons, contaminated soils from around the mill at the Upper Constitution were also excavated and disposed of in the CIA. A subsurface wetlands treatment facility to address adit and seep drainage was installed at this site in 2000; however, most of the tailings, and the waste rock dump at this site are located on private land, and have not been addressed to date.

A CERCLA non-time critical action was also implemented at the Sidney (Red Cloud) mine and mill site during the 1998, 1999, and 2000 field seasons. This action included removal of contaminated soils from around the mill site, regrading the waste rock dump, installation of run-on and run-off controls and on-site culvert improvements. Excavated soils were disposed of in the CIA. BLM has plans to close the adit and treat the drainage in a wetlands treatment system (Fortier, 2000).

In the 1999 field season, the east fork of Pine Creek was also diverted around the waste rock dump at the Highland Surprise mine and mill site in order to reduce erosion. As most of the facilities at this site are on private land, no other actions have been taken to date.

In 1995, the private owner of the Nabob Mine property installed a soil cover over the tailings pile and a portion of the mill area. The cover was revegetated with limited success (BLM, 1998). In the 1998 and 1999 field seasons, BLM implemented channel improvements through this reach to help stabilize the channel and prevent erosion of the tailings pile embankment. Stream channel stabilization, including barbs and in-stream structures have been implemented since 1997 in Denver Creek and the East Fork of Pine Creek to improve riparian habitat (Stevenson, 1998).

1.2.4.7 Prichard Creek

Previous clean-up action in the Prichard Creek watershed consists of some isolated portal closures conducted by the USDA Forest Service in the 1998, 1999 and 2000 field seasons. A non-time critical CERCLA removal action is planned by the USDA Forest Service for implementation at the Paragon Mine in the Prichard watershed for the 2001/ 2002 construction season. A non-time critical CERCLA removal action is also planned for the Jack Waite mine and mill site on the East Fork of Eagle Creek, a tributary of Prichard Creek. Sampling in support of development of an engineering evaluation and costs analyses (EE/CA) is currently being performed to support decision-making for the cleanup of this site. The Forest Service is working under an agreement with an identified potential responsible party to facilitate this clean-up action (Johnson, 2000).

The Prichard watershed is included in an integrated watershed analysis of the Prichard, Beaver and Eagle Creek drainages that is being currently performed for the Forest Service and Bureau of Land Management by the United States Geological Survey. The watershed analysis is being used to help assess the environmental and human health risks, and to establish priorities for reclamation work at numerous abandoned mine sites located in the National Forest lands in these watersheds (Johnson, 2000).

1.2.4.8 Upper South Fork Coeur d'Alene River (to Wallace)

Several clean-up actions have been implemented in the upper South Fork Coeur d'Alene River watershed above Wallace. These actions include several local actions identified to protect human health, and other response actions as implemented by the mining companies and the Union Pacific Railroad. During the 1998 and 1999 field seasons, the USACE on behalf of EPA performed several residential soil cleanups determined to be necessary to protect human health. These actions include removals at 5 residential properties within this portion of the watershed, and a localized removal at the Mullan City Park (USEPA, 1999, and USEPA 2000a). In addition, localized removals with replacement by wood chips were conducted beneath the play equipment at the Mullan Elementary School (USEPA, 2000c). Material from these removal actions was disposed of at the CIA (USEPA, 1999 and USEPA 2000a).

In 1989, Hecla directed adit drainage from the Morning Mine No. 6 Adit to a subsurface flow rock-bed filter treatment system located on top of the Morning Mine waste rock dump. Water quality data indicates variable effectiveness (Harvey, 2000).

As a part of the Consent Decree for the UPRR Wallace-Mullan Branch, contaminated soils and ballast within the UPRR right of way (ROW) along the South Fork Coeur d'Alene River (SFCDAR) above Wallace are to be covered with an asphalt, gravel or soil barrier, depending upon location. This action also includes limited removals of contaminated materials within selected railroad sidings in Mullan, and near the Lucky Friday Waste Impoundment. Thirty-two residential areas that are located within or encroaching onto the UPRR ROW are to be sampled as a part of this action; depending upon sample results, any residual contamination adjacent to these homes will be addressed. This action also includes fencing as access control around encroachments onto the ROW by the Hecla Lucky Friday Tailings Impoundment and the Morning Mine waste dump. A channel with wetlands planting is also included to collect identified seeps from the toe of the Morning Mine Waste Dump and discharged to the South Fork (MFG, 1999). Implementation of this portion of the UPRR Response Action is also planned for the year 2000-2001 (MFG, 2000).

1.2.4.9 South Fork Coeur d'Alene River (Wallace to Pinehurst)

Excluding the actions within the Bunker Hill Superfund Site, several other clean-up actions have been implemented in the South Fork Coeur d'Alene River (SFCDR) watershed between Wallace and Pinehurst. These actions include several local actions identified to protect human health, and other response actions as implemented by the SVNRT and the UPRR. During the 1997, 1998, 1999 and 2000 field seasons, the USACE on behalf of EPA performed residential soil cleanups at 20 properties determined to be necessary to protect human health (USEPA 1999, 2000a and 2000b). Localized removals have also been conducted at the Osburn Elementary and Middle schools. Grading and hydroseeding of the Osburn football field was completed in 2000. Clean-up activities were also implemented at the City Park, and Monument Park in Wallace. Material from these removal activities was disposed of at the CIA (USEPA, 1999). Also during 2000, five homes in the Polaris area were connected to the public water system and one home in Wallace was placed on an end-of-tap water purification system. Road-based and river-based human health advisory signage was also installed (USEPA, 1999).

In 1998, the SVNRT performed removals of sediment and tailings from the floodplain of the South Fork Coeur d'Alene River. Removals included 58,000 cubic yards from the Osburn Flats, 50,000 cubic yards from the Big Creek Flats, 20,000 cubic yards from the Evolution Bridge area and 7,000 cubic yards from Silverton (USEPA, 1997). These materials were transported to the CIA for disposal, and the removed area was regraded and revegetated. Channel bank armoring with riprap and rock groynes current deflectors were also added in the SFCDAR channel reach upstream of Big Creek (Calibretta, 1998).

Other work by the SVNRT in 1998 in the Osburn Flats area included large rock riprap channel bank armoring, construction of a high-water channel in the excavated removal area, and installation of a 3-acre soil amendment test pilot with piezometers. Results of test pilot are not known (IDSBWG, 1998).

In 1998, the Idaho Department of Transportation installed a clean barrier over contaminated materials in their ROW yard in Wallace to control dust and human exposure (IDSBWG 1998).

In 1993 and 1994 the SVNRT also performed a removal and bank stabilization project on the South Fork upstream of Elizabeth Park. This project included stabilization of a short reach of the river using riprap. This resulted in significant erosion downstream of the project including a washout of a portion of the UPRR embankment (Liverman 2001). Some additional removal and stabilization efforts were conducted in 1999 and 2000 in the previously eroded areas (Liverman 2001).

In 1994, the SVNRT performed limited tailings removals from the Elk Creek Pond near the confluence of Moon Creek with the South Fork Coeur d'Alene River, and placed clean beach sand along the north shore to prevent human exposure (IDEQ, 1998). Under a time-critical removal action during the 2000 field season, the EPA removed a total of 28,000 cubic yards of contaminated sediments and tailings from the Elk Creek Pond near the confluence of Moon Creek with the South Fork Coeur d'Alene River. These materials were disposed of in the Central Impoundment Area of the Bunker Hill Site. Additional work to channelize the pond, and stabilize the bed and banks is being planned for 2000/2001 (Liverman, 2000).

As a part of the Consent Decree for the UPRR Wallace-Mullan Branch, contaminated soils and ballast materials within the UPRR ROW along the SFCDAR between Wallace and Pinehurst are to be covered with an asphalt, gravel or soil barrier, depending upon location. This action also includes limited removals of contaminated materials within selected railroad sidings in Osburn and Wallace. Eighteen (18) residential areas that are located within or encroaching onto the UPRR ROW are to be sampled; depending upon sample results, any residual contamination adjacent to these homes will be addressed. This action also includes fencing around the Burns-Yaak Waste Rock Dump ROW encroachment and an adit closure in the ROW in Silverton. Fencing is also provided to prevent access to the Hercules mill site, and to limit access in the Wallace Rail yard to a 26-foot wide corridor of the ROW; the Wallace Yard area outside of this corridor is not included in the Consent Decree with UPRR (MFG 1999a, 1999b and UPRR, 1999). Fencing, large boulders and hostile vegetation are used to prevent access to contaminated areas along the River at portions of the ROW near Gene Day Park, the Shont siding near Big Creek, High Water Road and Pinehurst. Implementation of this portion of the UPRR Response Action is also planned for the year 2000/2001 (MFG, 2000).

1.2.4.10 North Fork Coeur d'Alene River

Previous clean-up actions in the North Fork Coeur d'Alene River watershed consist of some isolated portal closures conducted by the USDA Forest Service in the 1998, 1999 and 2000 field seasons (Johnson, 2000). There are no other known previous cleanup actions in this watershed.

1.2.4.11 South Fork and Main Stem Coeur d'Alene River (Pinehurst to Cataldo)

Several clean-up actions have been implemented in the South Fork Coeur d'Alene River watershed between Pinehurst and Cataldo. These actions include several local actions identified to protect human health, and other response actions as implemented by the EPA and the Union Pacific Railroad. During the 1999 field season, the USACE on behalf of EPA performed a residential soil cleanup in Pinehurst determined to be necessary to protect human health (USEPA 1999). Material from this removal was disposed of at the CIA (USEPA, 2000a). Another home in Pinehurst was connected to the public water system. Road-based and river-based human health advisory signage was also installed (USEPA, 1999).

As a part of the Consent Decree for the UPRR Wallace-Mullan Branch, contaminated soils and ballast materials within the UPRR ROW along the SFCDAR between Pinehurst and Cataldo are to be covered with an asphalt, gravel or soil barrier, depending upon location. This action also includes limited removals of contaminated materials within selected railroad sidings near Enaville and Cataldo. One home adjacent to the UPRR ROW will be sampled; depending upon sample results, any residual contamination will be addressed. Fencing, large boulders and hostile vegetation are used to prevent access to contaminated areas along the River at portions of the ROW near the Hangaard arena, Enaville and the old CCC Road west of Enaville (MFG, 1999). Implementation of this portion of the UPRR Response Action is also planned for the year 2000/2001 (MFG, 2000).

1.2.4.12 Lower Coeur d'Alene River (Cataldo to the Lake)

There have been several previous clean-up actions in the Lower Coeur d'Alene River, with a focus primarily on erosion control and areas with human recreational use. Several projects have been implemented at the Cataldo Mission and State Park. In 1995, the Coeur d'Alene Tribe removed about 700 cubic yards of contaminated materials from the campground at the Mission; these materials were transported to the Roosevelt Landfill in Washington for disposal (REI, 1995). In 1998, IDEQ installed cabled log bank protection and brush wattling to reduce erosion near the Cataldo Boat Ramp. In addition, hostile vegetation (Black hawthorne) bushes were planted in the vicinity of contaminated soils to reduce the risk of human exposure (IDSWB, 1998).

Private land owners have experimented with soil amendments to improve the agricultural productivity of tailings-contaminated soils in the Lower Coeur d'Alene or to decrease leachability of metals (Frutchey 1994).

In 1998, a pilot project was implemented in a portion of the Cataldo Flats by the Mine Owners Association, USEPA, IDEQ and the University of Idaho Water Resources Research Institute to assess the effectiveness of various in-situ soil treatment processes. Processes included silica encapsulation, apatite mineralization, phosphate addition and apatite II application. The results were variable, but generally resulted in decreased leachability of both lead and zinc (Williams et al. 1999).

During the 1999 field season, the USACE on behalf of USEPA performed a residential soil cleanup in Cataldo determined to be necessary to protect human health (USEPA 1999). Material from this removal was disposed of at the CIA (USEPA, 2000a). Drinking water was addressed at two locations in Cataldo with one home receiving an end-of-tap purification system and another being connected to the public water system. Under a time-critical removal action in 1999, USEPA worked with Idaho Fish and Game to install an asphalt barrier at the public boat launch sites at Anderson and Thompson Lakes. Asphalt paving with rock riprap bank protection, and access controls (boulders and hostile vegetation) were added to both locations. Road-based and river-based human health advisory signage was also installed (USEPA, 1999).

In 1999, the USDA Forest Service also implemented several measures to protect human health at the Medimont boat launch and Rainy Hill campgrounds. These measures included providing an aggregate barrier in the parking lots, placement of angular rock riprap along the shoreline to prevent children's play in contaminated bank materials, placement of large boulders to prevent access to the more contaminated areas and enforcement of overnight camping restrictions. Several mining companies contributed funding towards this project (Johnson, 2000).

In 1994, a previous bank erosion control project was implemented at Medimont by IDEQ and the Soils Conservation Service (now the National Resource Conservation Service). Four types of erosion control were placed at the Medimont bend in the Coeur d'Alene River, two with hay bales, two with riprap. Subsequent monitoring indicated that the hay-bale methods were not effective in this portion of the river (Harvey, 2000).

In 1999, the Silver Valley Natural Resource Trustees installed a pilot bank erosion project to evaluate effectiveness of rock berms in reducing bank erosion cased by piping, or undercutting by boat wake. The project included minor bank regrading and shaping along 750 feet of a straight portion of the river channel near Dudley, with installation of riprap channel bank armoring and rock berms along the overbank (SVNRT, 1998).

Idaho Fish and Game installed a water control structure in Swan Lake in 1994 to regulate the water level in this surface water body. In the following years, they have provided ongoing water level control in the fall and winter to allow access for hunting and fishing. The raised water level also has effects of limiting geochemical reactions in the sediments and limiting human and wildlife access to these contaminated materials (Nigh, 1995).

As a part of the Consent Decree for the UPRR Wallace-Mullan Branch, contaminated soils and ballast materials within the UPRR ROW along the lower Coeur d'Alene River between Cataldo and Harrison (Coeur d'Alene Lake) are to be covered with an asphalt, gravel or soil barrier, depending upon location. This action also includes limited removals of contaminated materials within railroad sidings near Cataldo, Dudley, Lane, Bare Marsh, Springston, and Harrison. Seven homes adjacent to the UPRR ROW will be sampled; depending upon sample results, any residual contamination will be addressed. Fencing, large boulders and hostile vegetation will be used to prevent access to contaminated areas along the River at portions of the ROW near Medimont, Dudley, Lane, Bull Run, and Cataldo (MFG, 1999). Implementation of this portion of the UPRR Response Action is planned for the year 2001-2002 (MFG, 2000).

1.2.4.13 Coeur d'Alene Lake

Within the area adjacent to Coeur d'Alene Lake, there have been very few previous clean-up actions. The 1996 Coeur d'Alene Lake Management Plan was developed to outline measures to address the condition of the Lake. Activities previously implemented include:

- Placement of mine wastes in settling basins and tailings impoundments instead of directly discharging them into the river.
- Installation of sewage treatment technologies to reduce nutrient loading,
- Implementation of aggressive sediment runoff controls by the Forest Service,
- Cessation of nutrient discharges by the phosphate fertilizer plant, and
- Imposition of nearshore erosion controls.

In 1999, the USDA Forest Service performed a CERCLA time-critical removal action to remove contaminated soils and waste rock/ore dumps from the Silver Tip Mine on Varnum Creek and the Gray Wolf Mine located on Beauty Creek, tributaries of the northern portion of Coeur d'Alene Lake. Approximately 3,000 cubic yards of material were removed from these sites and placed into the combined waste containment in the Moon Creek watershed. This action also included two portal closures and installation of a limestone drain at the Silver Tip mine to intercept acid mine drainage (Johnson, 1999).

As a part of the Consent Decree for the UPRR Wallace-Mullan Branch, contaminated soils and ballast within the UPRR ROW along the Lakeshore south of Harrison beginning at the Coeur d'Alene Reservation boundary are to be removed and properly disposed of. Sampling is currently being performed to determine the extent of removals, and also the need for potential sediment removals or other remediation for the wetlands in this area; the removals are scheduled for the 2001/2002 field seasons (MFG, 2000). North of the Coeur d'Alene Reservation boundary, including Harrison, asphalt and soil barriers are planned for the rail embankment, along with placement of an 18-inch thick sand barrier over the public beach in Harrison. Implementation of this portion of the UPRR Response Action is also planned for the year 2001/2002 (MFG, 1999).

1.2.4.14 Spokane River

There have been no known previous cleanup actions in the Spokane River watershed. As an interim measure, Human Health Advisories have been issued by the Spokane Regional Health District regarding fish consumption, and the use of beaches and other recreational areas along the Spokane River with contaminated sediments (Roland, 2000 and HHRA, 2000).

1.3 BASIN DEMOGRAPHICS

In general, demographic data are presented according to geographic divisions. Geographic divisions include geographic areas as well as counties and cities. The primary source for these demographics is 1990 census data, as described in the human health risk assessment (HHRA) for the Basin (Terragraphics 2000). The HHRA evaluated the 1990 census data for Shoshone County, Idaho against more recent information and found that the population of the county had not altered substantially since 1990. However, County Profile Data for Kootenai County, Idaho and Historical/Current Data for Spokane County, Washington indicate that the populations of these counties are steadily increasing. Population information is summarized in Table 1.3-1.

With the exception of three larger cities (Coeur d'Alene, Post Falls, and Spokane) the majority of the Basin is rural, undeveloped land. A good portion of the Basin consists of federally managed lands, primarily National Forest Lands (IPNF 1998). These areas are rich in natural resources including forests, wildlife, and a number of tributaries and streams that support a variety of aquatic organisms. However, many of these areas are inaccessible due to the lack of roads and the difficult terrain. Interstate 90 (I-90) has provided limited access to the otherwise rural area. I-90 spans East to West along the South Fork Coeur d'Alene River, then just north of Coeur d'Alene Lake through the cities of Coeur d'Alene and Post Falls, and continues west along the Spokane River through the city of Spokane where the river turns northward and I-90 turns southward. From here, there are little more than small rural back roads.

Despite the recent economic growth, the lack of development in the upper portion of the Basin has resulted in many small rural communities, primarily along the Coeur d'Alene River and its tributaries. The majority of the population of the Basin lives in the cities of Coeur d'Alene and Post Falls, ID and Spokane, WA, which have populations exceeding 24,563, 7,349 and 177,196 people, respectively. All the other communities in the Basin have populations below 2,000.

The total population of the study area is 242,262. Ninety-eight percent of the study area is in the state of Idaho and the remaining 2 percent is in the state of Washington. However, because the largest city in the Basin study area, Spokane, is included in the total population of the study area, 81 percent of the study population resides in Washington and only 19 percent of the study population resides in Idaho.

Much of the Coeur d'Alene River Basin consists of National Forest Lands. Approximately 32 percent of Kootenai County and 75 percent of Shoshone County consist of federally managed lands. Therefore, most of the lands along the river and its tributaries are sparsely populated, except for several small communities along the South Fork. Mullan, Wallace, Silverton, Osburn, and Kingston, Kellogg and Smelterville, and a few communities along the Lower Coeur d'Alene River, primarily Cataldo and Harrison, are the locations of the majority of the population in this portion of the Basin. However, Kellogg and Smelterville are part of the Bunker Hill Superfund site and have been excluded from this investigation. The areas within the study area are estimated to include approximately 5,500 homes (Terragraphics 2000).

The areas around Coeur d'Alene Lake include two of the three largest cities in the Basin study area, Post Falls and Coeur d'Alene, ID. The other communities surrounding the lake are small and primarily rural in nature. It is a prime recreational area with picnic and camping locations intermittently dispersed between communities.

The Spokane River Basin spans from the head of the Spokane River at Coeur d'Alene Lake to the confluence with the Columbia River at Lake Roosevelt. The primary population center along the river is the city of Spokane that has a population of approximately 177,196 and is the second largest city in the State of Washington. In addition, there are several small communities along Long Lake, but demographic data for this area is limited.

The basin also includes the Spokane and Coeur d'Alene Indian Reservations (Tiller 1996). The Coeur d'Alene Reservation, within the Coeur d'Alene basin in Kootenai and Benewah Counties Idaho, comprises 345,000 acres of primarily agricultural and forest lands. The total reservation population is approximately 6,000. Tribal governmental offices are located in Plummer, the largest town on the reservation.

The Spokane Reservation, within the Spokane River basin in Stevens County, Washington, comprises about 155,000 acres of mostly forested lands. The total Reservation population is just under 1,500. Tribal governmental offices are located in Wellpinit.

All lands in the basin are within the aboriginal lands of the Coeur d'Alene and Spokane Tribes.

1.4 REPORT ORGANIZATION

The content and organization of this report are based on EPA's *Guidance Document for Conducting Remedial Investigations and Feasibility Studies under CERCLA, Interim Final* (USEPA 1988).

The remedial investigation report is divided into seven parts.

- Part 1—Setting and Methodology (this part), which includes descriptions of regional information, including the conceptual site model (CSM); physical setting (meteorology, geology, geochemistry, hydrogeology, hydrology, ecology, and demographics); site history and investigation summary; and evaluation methodology and screening criteria

- Part 2—Remedial investigation results for CSM Unit 1, Upper Watersheds (Beaver Creek, Big Creek, Canyon Creek, Moon Creek, Ninemile Creek, Pine Creek, Prichard Creek, and Upper South Fork Coeur d'Alene River)

- Part 3—Remedial investigation results for CSM Unit 2, Midgradient Watersheds (South Fork Coeur d'Alene River, Main Stem Coeur d'Alene River, and North Fork Coeur d'Alene River)

- Part 4—Remedial investigation results for CSM Unit 3, Lower Coeur d'Alene River and Floodplains

- Part 5—Remedial investigation results for CSM Unit 4, Coeur d'Alene Lake

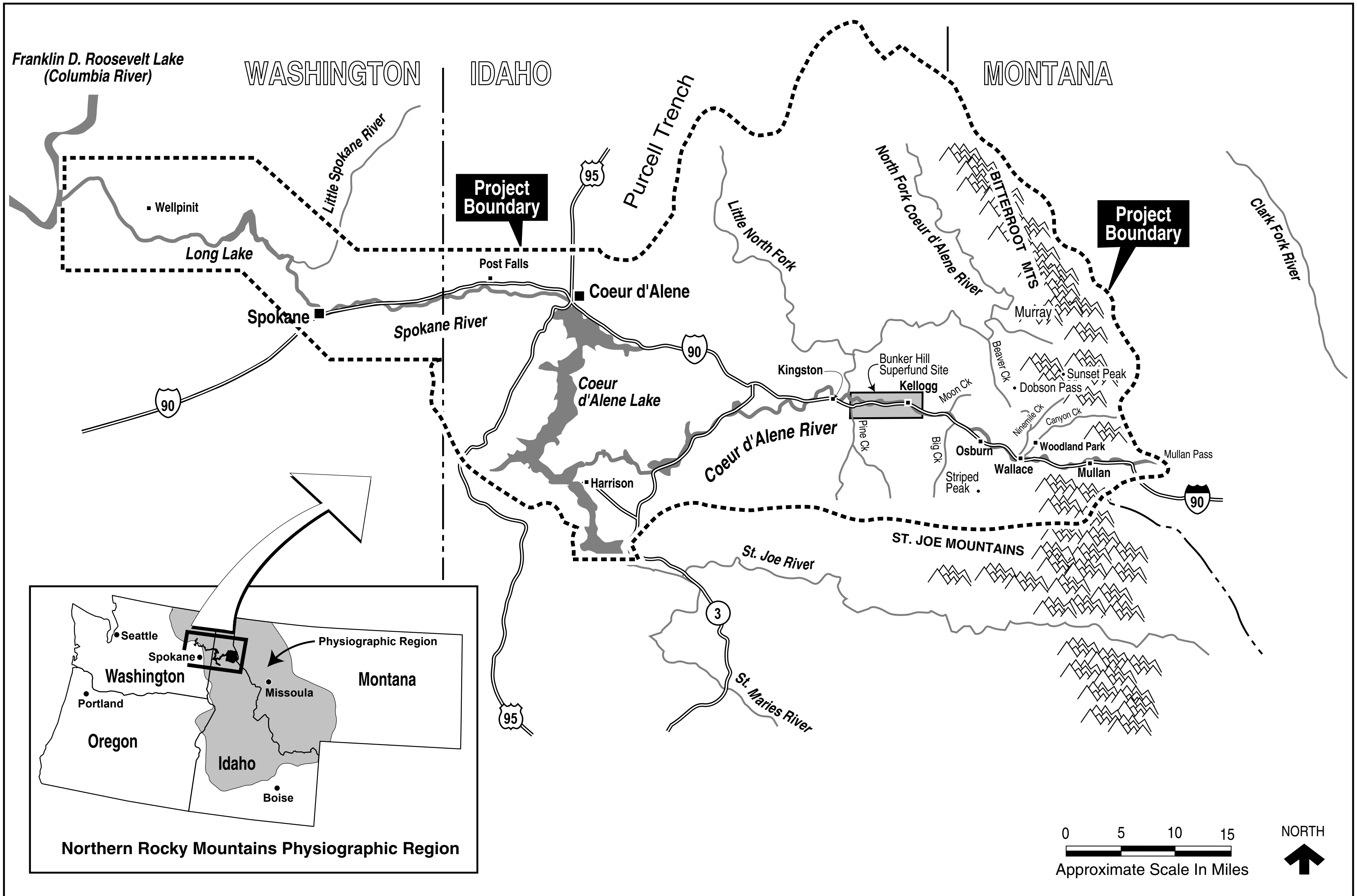
- Part 6—Remedial investigation results for CSM Unit 5, Spokane River

- Part 7—Summary of the remedial investigation, which includes a summary of findings for each of the five CSM units and presents an overall evaluation of the basin as a whole. (For the reader's convenience, Part 7 has been bound into Volume 1 with Part 1.)

Parts 2 through 6 contain individual RI reports for each of the 14 watersheds identified in the study area (see Part 1, Section 2 – Conceptual Site Model Summary). Each individual watershed report contains:

- Section 2—Physical Setting, including discussions on geology, geochemistry, hydrogeology, hydrology, and demographics of the specific watershed
- Section 3—Sediment Transport
- Section 4—Nature and Extent of Contamination, including a summary of chemical results and estimates of mass loading from source areas
- Section 5—Fate and Transport, including physical and chemical transport processes of contaminants

Risk evaluations and potential remedial actions associated with source and depositional areas are described in the human health risk assessment, the ecological risk assessment, and the feasibility study (all under separate cover).



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Coeur d'Alene Basin RI/FS
RI REPORT

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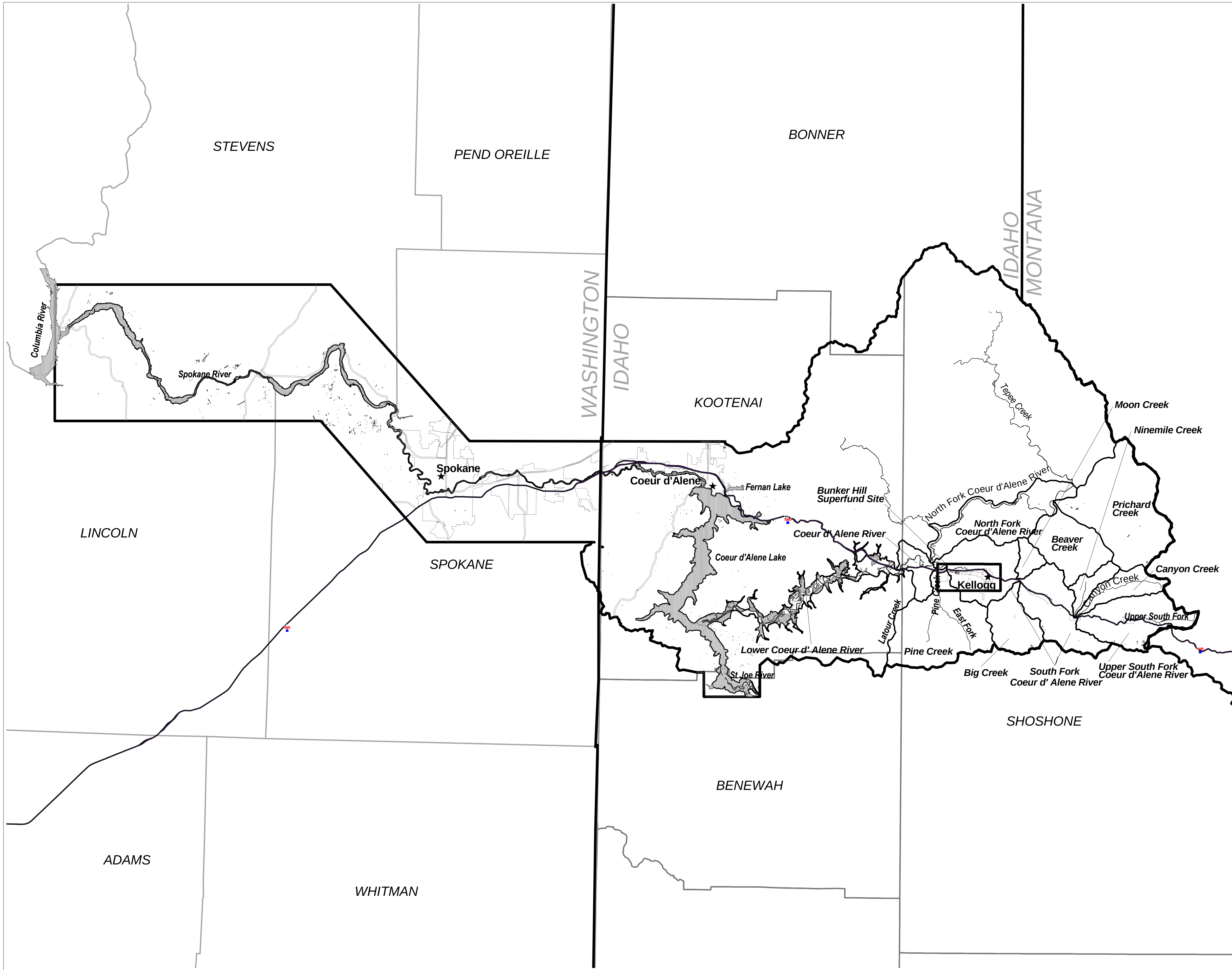
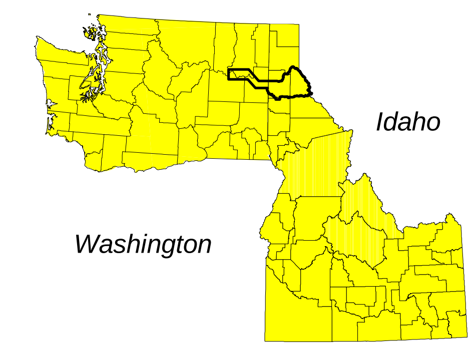
Figure 1.2-1
Project Location Map

Figure 1.2-2
Coeur d'Alene Basin RI/FS
Watershed Boundaries



LEGEND

- ★ Cities
- Roads
- Interstate / Highway
- Lakes and Rivers
- City Boundaries
- Watershed Boundaries
- Counties
- Bunker Hill Superfund Site



Location Map

NOTES

1) **Base map coverages obtained from the Coeur d'Alene Tribe, URS Greiner, Inc., CH2M HILL, and the Bureau of Land Management**

SCALE 1:680,000

0 **10 Miles**

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027-RI-CO-102Q
Coeur d' Alene Basin RI/FS
RI REPORT

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L: Final RI Fig 1-2
7/18/2001

This map is based on Idaho State Plane Coordinates West Zone, North American Datum 1983.

Date of Plot: July 18, 2001

Table 1.3-1
Summary of Basin Geographic Areas and Population

Location	Total Area (mi^2)	Portion of Area in Basin (mi^2)	Basin %[a]	Total Population	Portion of Pop in Basin	Basin %[a]
Counties						
Bonner County, ID	1,911	20	2%	26,662	-	0%
Benewah County, ID	782	9	1%	7,937	-	0%
Shoshone County, ID	2,632	1,001	76%	13,931	6,970	3%
Kootenai County, ID	1,304	261	20%	69,795	38,140	15%
Spokane County, WA	1,774	6	0.5%	361,364	197,055	82%
Lincoln County, WA	2,332	5	0.4%	8,864	11	0%
Stevens County, WA	2,531	9	1%	30,948	86	0%
Total	13,266	1,311	100%	519,501	242,262	100%
Basin Study Areas						
CSM Unit 1	1,034	--	79%	7,066	--	3%
CSM Unit 2	172	--	13%	5,132	--	2%
CSM Unit 3	35	--	3%	1,000	--	<1%
CSM Unit 4	49	--	4%	31,912	--	13%
CSM Unit 5	21	--	2%	197,152	--	82%
Total	1,311	100%	100%	242,262	100%	100%

Source: 1990 Census Data
[a]The percentage each county makes uppp of the basin area.
[b]See Section 2.0 for descriptions of basin study areas.
Note: < - less than

2.0 CONCEPTUAL SITE MODEL SUMMARY

2.1 INTRODUCTION

A conceptual site model (CSM) is often used to convey a summary of the sources of contamination, mechanisms of contaminant release, pathways of contaminant release and transport, and the ways in which humans and ecological resources are exposed to contaminants. These were the general purposes for the development of a CSM for the Coeur d'Alene basin Remedial Investigation/Feasibility Study (RI/FS). However, for this large and complex site, the CSM also provides a basis for assembling information about the basin and data from diverse sources into a structure that allows systematic analysis of specific sources of contamination at an adequate level of detail, while maintaining an understanding of the overall context of the effects of all of the important sources of contamination. The underlying structure of the CSM is also used in this report as a way of organizing and presenting site information. This will facilitate the analysis of potential remedial actions and alternatives at appropriate spatial scales. The detailed CSM is published under separate cover (CH2M HILL 2000). This section is a summary of that document.

A hierarchical approach was used for the CSM. In this approach, concepts of physical relationships of sources of mining waste and the lands and waters of the basin, chemical and physical processes causing releases, fate and transport of mining wastes, and affected resources are presented as a series of diagrams, tables, and text. The diagrams represent the general relationships between entities (e.g., waste sources) and processes (e.g., transport mechanisms) and are composed of expandable "nested" elements that are themselves expanded in additional diagrams, tables, or text if needed to illustrate or understand greater detail than can readily be shown on a single diagram. To facilitate analysis of processes at work in the basin, parts of the basin with similar geomorphology, stream gradients, and amounts and types of mining wastes were grouped into CSM units (Figure 2.1-1).

The CSM units have a fairly large geographic scale, but are sufficiently homogeneous that types of waste sources, mechanisms of release and transport of waste, and the ecological resources affected by the release of contaminants are similar in each CSM unit. The CSM units were numbered from upstream to downstream (one through five). Each of the CSM units was further divided into smaller components. For CSM Unit 1, which comprises most of the larger, upper tributaries in the Coeur d'Alene basin, individual watersheds (e.g., Canyon Creek, Ninemile Creek) were selected as an intermediate subdivision because risk assessments and ongoing and future remedial actions could be conducted at a watershed scale.

The watersheds in CSM Unit 1 and the other CSM units were further divided into segments based on more detailed geomorphology and other characteristics. Table 2.1-1 lists the segments within each CSM unit. Parts 2 through 6 of the RI contain maps that identify the segments within each watershed. There is no analysis at the watershed level for CSM units 2 through 5. More detailed analysis has been done at the CSM segment level, discussed below for the individual CSM units.

The CSM was developed by EPA contractors and refined through a series of meetings and workshops with participation by staff from EPA and their contractors, from federal natural resource agencies (U.S. Bureau of Land Management, U.S. Forest Service, U.S. Fish and Wildlife Service, and U.S. Geological Survey) and their contractors, the Coeur d'Alene Indian Tribe and their contractors, the Spokane Tribe, and the States of Idaho and Washington. The workshops were used to inform EPA and its contractors of the extensive body of information about the Coeur d'Alene basin that had been previously developed or was in the process of development by others, to establish collaborative relationships for additional work done for the RI/FS, and to determine whether EPA needed to do additional sampling or studies in the Coeur d'Alene basin.

During the workshops and other meetings, EPA sought information and opinions regarding where continuing or threatened future releases of hazardous substances (metals) from mining wastes and the greatest effects of past releases were likely to occur. That information and those opinions are reflected in the CSM by intentional omission of many tributary watersheds (e.g., Lake Creek and Placer Creek) with no indication of significant problems with ongoing releases of metals from mining waste and little or no indication of continuing effects of past releases. Smaller tributaries to the South Fork of the Coeur d'Alene River, while having the geomorphology of the CSM Unit 1 tributaries, were included in CSM Unit 2, and are not individually shown in Table 2.1-1. However, in the CSM database, drainages within watersheds were identified, and the locations of sources of mining waste are identifiable to the drainage level, if necessary.

Another basis for inclusion of a part of the Coeur d'Alene basin as a CSM component was loading of metals (cadmium, lead, and zinc) to waters of the basin in that part of the basin. Concepts formulated in the CSM are based on conclusions drawn based on those data (MFG, 1991, 1992), IDEQ unpublished data, and some data collected for this RI. Subsequent and more detailed analyses of metals loading presented in the nature and extent of contamination section for each segment will be the basis for selection of areas for analysis in the FS. The loading tables in the CSM are quantitative point estimates for some places in the basin, and integrated (e.g., annual) estimates for some places depending on the information available and the amount of analysis that had been done by others.

The CSM (CH2M HILL 2000) also contains tables for some units and segments that estimate current and future desired ecological conditions, current and desired metals loading, and management options (remedial technologies) that might be used, and preliminary lists of ecological receptors. Those components were included to provide perspective for the CSM with regard to other parts of the RI/FS and to promote the exchange of information with staff working on risk assessments and the FS.

In a general sense, the size, complexity, and history of releases of metals from mining waste have caused a diversity of environmental and potential human-health effects that vary across the basin. In the upper basin, ongoing releases of metals to water cause severe limitations on aquatic ecosystems in areas affected by mining wastes. Metals in floodplain soils are likely to cause hazards to plants, wildlife, and humans. In the lower basin, below the confluence with the North Fork Coeur d'Alene River and beyond, ongoing releases of metals to water are diluted by flows of clean streams and are of lesser concern, but the depositional environment (of sediment) and low gradient favor the occurrence of wetlands and agricultural areas where the deposition of lead in soil by floodwaters causes hazards to wildlife. Humans may be at risk from exposure to metals (primarily lead) through broad areas within the Coeur d'Alene basin.

While discussing future ecological goals during workshop sessions, it became apparent that non-mining-related actions impose limitations on the ecological potential of some mining-waste-affected areas. While discussing the potential target ecological conditions shown in the CSM, an attempt was made to account for the limitations to the potential for recovery of natural resources caused by non-mining-related factors and actions. The mining and non-mining factors and actions are called disturbances as noted on Figure 2.1-2, which shows how the disturbances cause stresses that act through effects pathways and can adversely affect the same ecological resources that are also affected by releases of metals from mining waste. Figure 2.1-2 is a generalized representation of the entire Coeur d'Alene basin, with some disturbances being more important in some parts of the basin than in others. Draft lists of ecological receptors shown in the CSM can be found in CH2M HILL 2000; they have been refined and replaced with a single table in the Ecological Risk Assessment (Eco RA under separate cover).

A Source Area Table was developed as part of the CSM (CH2M HILL 2000) based on Geographic Information System coverages provided to EPA by the U.S. Bureau of Land Management (BLM 1997). The Source Area Table was established in the CSM database as a way of listing the numerous known and possible sources of mining waste in the Coeur d'Alene basin, and as a structure for assembling detailed information on important source areas for the RI/FS. The data provided by BLM has been added to by RI activities, and the Source Area Table has been altered to a Source Area List (Appendix I) to facilitate the description and identification of the important source areas in the nature and ex tent of contamination section for each segment.

2.2 CSM UNIT 1, UPPER WATERSHEDS

Based on past studies and sampling in the Coeur d'Alene basin, eight tributary watersheds, including the South Fork of the Coeur d'Alene River (South Fork) above Wallace, were included in this CSM Unit (Table 2.1-1). Six of these watersheds were further divided into two to five segments each, based on the presence or absence of mining activities, tributary streams, and stream valley morphology. Most of the effort and discussions during development of the CSM focused on Canyon and Ninemile Creeks, which, based on past studies, are clearly more important sources of metals loading from the tributaries to the Coeur d'Alene River system. Canyon and Ninemile Creeks also have the highest concentrations of metals among the larger tributaries outside of the Bunker Hill Superfund Site.

The Preliminary Process Model diagrams for all of the watersheds and segments of watersheds in CSM Unit 1 were very similar (CH2M HILL 2000). An example from Canyon Creek, Segment 5, is shown on Figure 2.2-1. The main differences between watersheds and between segments depended on the presence or absence of particular source types and the presence or absence of residential soils as an affected medium.

The main components of the Preliminary Process Model (e.g., inputs, primary source types) are shown across the top of the diagram (Figure 2.2-1). Inputs are the sources of metals, water, and sediment entering the upper boundary. Primary source types are sources, or potential sources of mining waste that are in locations where they were generated. Source types in Figure 2.2-1 are defined as follows:

- Mine workings: shafts and adits
- Waste rock: rock derived from mining activities (other than ore)
- Tailings: discarded fractions of ores
- Concentrates and other process wastes: ore concentrates, unprocessed ore, and other wastes related to mining

- Artificial fill: mining wastes intentionally placed as fill (e.g., for railroads, roadways and structures).

Primary release mechanisms are those that act on primary sources. The categories shown on Figure 2.2-1 are self-explanatory. Affected media and secondary sources are media where mining wastes now reside as a result of natural transport processes (e.g., erosion and deposition). The categories shown on Figure 2.2-1 are self-explanatory, except for alluvium. Alluvium in the context of the CSM means soils and other materials that have been transported by water to their present location, and usually are not covered by water. In the Coeur d'Alene basin, alluvium could consist entirely of naturally derived material or could be largely mining waste (e.g., water-transported tailings).

Secondary release mechanisms are those that act on affected media and secondary sources. Except for chemical processes, the secondary release mechanisms shown on Figure 2.2-1 are self-explanatory. Chemical processes are the various processes that result in the chemical transformation, dissolution, and sometimes precipitation of metals from secondary sources. The dissolution component is chemically similar to dissolution from primary sources.

Exposure routes (Figure 2.2-1) are the pathways and processes by which humans and living natural resources (receptors) might be exposed to metals from mining waste. The selection of receptors was done in the Eco RA and Human Health Risk Assessment.

The last column of the Preliminary Process Model (Figure 2.2-1) lists the geographic linkages to downstream segments or CSM units, and provides a way to account for the transfer of metals and other materials. Transfer of metals is evaluated further in the discussion of mass loading in the Nature and Extent of Contamination section for each watershed.

The pathways (connecting arrows) in the Preliminary Process Model were drawn with three different line weights to reflect the consensus of opinion during development of the CSM regarding the relative and absolute importance of the various pathways. The pathways of metals transport are further evaluated in the Fate and Transport section for each watershed.

CSM Unit 1 contains a large number of the mine and mill sites that are the primary sources of mining waste in the Coeur d'Alene basin. It is also the location of continuing releases of metals from mining waste to the Coeur d'Alene River system. The following sections briefly describe an understanding of each of the watersheds in CSM Unit 1 that are listed in the CSM (Table 2.1-1). Individual important sources of metals are described in the Nature and Extent of Contamination section for each watershed.

2.2.1 Beaver Creek

Beaver Creek was assigned to one segment. Mining and milling was done in the upper part of the Beaver Creek Watershed, tributary to the North Fork of the Coeur d'Alene River. The source area table (Appendix I) lists 74 potential source areas in upper Beaver Creek, including the Carlisle mine and mill site. Surface water was sampled in Beaver Creek in the fall of 1997. Concentrations of zinc exceeded 1,000 μg/L below the Carlisle mill site at that time, but were substantially reduced in the lower part of Beaver Creek.

Concentrations of metals in surface water in the upper part of Beaver Creek are likely to cause harm to aquatic life, but do not contribute significantly to metals loading in the lower part of the Coeur d'Alene basin.

2.2.2 Big Creek

Big Creek was divided into four segments in the CSM (Table 2.1-1). Segments 1 through 3 are the upper part of Big Creek and the East and West Forks of Big Creek. There are some potential source areas in segments one through three, but most of the potential sources are in segment 4, lower Big Creek (Appendix I).

Concentrations of metals in water from Big Creek were measured in May and October of 1991 and in November 1997 and May 1998. In all instances, concentrations of metals were low and did not indicate likely harm to aquatic life.

2.2.3 Canyon Creek

Canyon Creek, which has been impacted by mining activities and past and continuing releases of metals from mining wastes, is divided into five segments. Segment 1, Upper Canyon Creek above the Hecla water intake, has some potential source areas (Appendix I), but does not appear to receive much metals input currently based on sampling in Segment 1 and the upper part of Segment 2.

Segment 2 of Canyon Creek, from the Hecla water intake to the mouth of Gorge Gulch, has more potential sources in proximity to the creek, has relatively low concentrations of metals in surface water, and does not contribute significantly to metals loading to the Coeur d'Alene River system.

Segment 3 of Canyon Creek, Gorge Gulch, has a number of potential source areas (Appendix I) including the Hercules complex and others. Sampling of surface water at the mouth of Gorge Gulch indicates dissolved metals above the national ambient water quality criteria. It is possible, but not demonstrated, that additional metals loading enters Canyon Creek from Gorge Gulch as groundwater flow.

Segment 4 of Canyon Creek contains a large number of potential source areas (Appendix I). Concentrations of dissolved metals in surface water are well in excess (sometimes greater than 100-fold) of ambient water quality criteria, and about 100 to 300 pounds per day of zinc enter Canyon Creek in segment 4. Aquatic life is nearly absent from segment 4 of Canyon Creek. Most of the stream bed in segment 4 is in bedrock, but some interaction with contaminated groundwater is likely.

Segment 5 of Canyon Creek is the lower part of the watershed near Woodland Park. The valley broadens into a depositional basin in segment 5, with up to 40 feet or more of alluvium above the underlying bedrock in places, but narrows above the confluence with the South Fork of the Coeur d'Alene River. A former tailings dam at Woodland Park enhanced the deposition of tailings until the dam failed due to floods in 1917. There are fewer potential source areas in Segment 5 than in Segment 4 (Appendix I), but Segment 5 contains the Hecla-Star tailings ponds, which are, in aggregate, a very large feature. Concentrations of dissolved metals in Segment 5 exceed those in Segment 4, and aquatic life is nearly absent from Segment 5. Loading of dissolved zinc to Canyon Creek increases by about 200 to 400 pounds per day, depending on season. Significant interactions between surface water and groundwater occur in Segment 5 of Canyon Creek. In the upper part of Segment 5, surface water is lost to groundwater. The groundwater reenters the creek in the lower part of Segment 5, substantially enriched in dissolved metals. It is believed that groundwater interacts with floodplain tailings deposits under the Hecla-Star tailings ponds, and is augmented by mine drainage water discharged to the ponds.

Tailings deposits from the floodplain in Segment 5 of Canyon Creek have been excavated and placed in a new repository on the south side of the valley. The stream has been reconstructed with designed habitat features to favor the return of fish if metals concentrations become sufficiently reduced. Attempts to re-vegetate the floodplain have met with limited success, with grasses being the only plants surviving to any extent. Sampling for this RI suggests that some floodplain soils remain contaminated with metals. It is not known yet what the effects of tailings removal will be on loading or concentrations of metals in lower Canyon Creek. Monitoring of groundwater in the floodplain suggests that a plume of metals has formed in association with the new tailings repository.

2.2.4 Moon Creek

Moon Creek is divided into two segments in the CSM (Table 2.1-1). Segment 1, the West Fork of Moon Creek, has few potential sources of mining waste and is relatively unaffected. Segment

2, the remainder of Moon Creek including the East Fork, has potential source areas including the Silver Crescent mine and mill complex, and others (Appendix I). Mining and discharge of tailings from the mill sites on the East Fork have caused the deposit of mining wastes on the narrow floodplain of the lower part of Moon Creek and the East Fork. Concentrations of dissolved zinc in Moon Creek in Segment 2 exceed the ambient water quality criteria by up to two- to three-fold, and loading of dissolved zinc to the South Fork Coeur d'Alene River has been up to 48 pounds per day, but is more commonly less than 10 pounds per day.

Remedial actions at the Silver Crescent mine and mill complex have recently been completed by the U.S. Forest Service, and there are indications of improvement in water quality.

2.2.5 Ninemile Creek

Ninemile Creek, which has been very affected by mining activities, is divided into four segments in the CSM (Table 2.1-1). Segment 1, which is the upper part of the East Fork of Ninemile Creek above the Interstate mill site, has several potential source areas but no mill sites (Appendix I). Surface water samples collected near the downstream boundary of Segment 1 (location NM291) indicate concentrations of metals in excess of the ambient water quality criteria by up to four-fold. Samples collected a short distance upstream (locations NM289 and NM290) do not exceed the ambient water quality criteria. It is not known if location NM291 is affected by the tailings and other waste material at the Interstate mine site, but important source areas upstream of the Interstate mill site have not been indicated.

Segment 2 begins on the East Fork above the Interstate mill site and ends at the confluence of the East Fork with the main stem of Ninemile Creek. This segment contains most of the source areas in the Ninemile Creek watershed (Appendix I). Important source areas are indicated in the nature and extent of contamination section for each segment Concentrations of dissolved metals exceed the ambient water quality criteria by up to 100-fold or more (zinc to 6,570 μg/L), and aquatic life is essentially absent from Segment 2 of Ninemile Creek. Up to about 400 pounds of zinc per day enter Ninemile Creek in Segment 2. Some response actions have been taken at the Interstate mill site with the intent of reducing the loading and concentrations of metals in Ninemile Creek. The effectiveness of the response actions is not yet known.

Segment 3 is Ninemile Creek above the confluence with the East Fork. There are several potential source areas in Segment 3 (Appendix I), but little evidence of metals contamination within surface waters in the watershed. Concentrations of dissolved metals may approach, or even slightly exceed, ambient water quality criteria during low flows (e.g., November 1997), but the potential toxicity of dissolved metals is reduced by the naturally higher alkalinity of the water in Segment 3 of Ninemile Creek.

Segment 4 is Ninemile Creek below the confluence with the East Fork. There are potential source areas in Segment 4 (Appendix I), but their contribution of metals, if any, is less than the reduction in metals concentrations and loading that occurs in this segment. It appears that the alkalinity contributed from Segment 3 causes a significant reduction in the metals concentration and load discharged from Segment 2 of Ninemile Creek. In spite of the mitigating effect of the alkalinity from Segment 3, concentrations of dissolved metals in Segment 4 remain high enough to significantly affect aquatic life, which is nearly absent from this segment.

Despite the reduction in metals loading that occurs in Segment 4, Ninemile Creek contributes up to 400 or more pounds per day of zinc and other metals to the South Fork Coeur d'Alene River.

2.2.6 Pine Creek

Pine Creek is divided into three segments in the CSM (Table 2.1-1). Segment 1, the East Fork of Pine Creek and tributaries, contains most of the potential source areas in the watershed (Appendix I). Concentrations of dissolved metals exceed ambient water quality criteria by up to about 10-fold at the downstream end of Segment 1, and zinc loading is on the order of tens of pounds per day. Some mining wastes have been removed from BLM lands and taken out of the watershed to the Central Impoundment Area near Kellogg. However, at several of the mines and mill sites where work was done by BLM, wastes remain on private land. Some of these wastes may be discharged with ongoing erosion to the creek during high flows. Aquatic life, including trout, are present in many places with suitable habitat in Pine Creek Segment 1.

Segment 2 of Pine Creek, upper Pine Creek and tributaries, has a number of potential sources of mining waste, but no tailings deposits (Appendix I). Releases of metals to the creek are minimal, and ambient water quality criteria do not appear to be exceeded.

Segment 3 is lower Pine Creek from the confluence of the East Fork to the South Fork Coeur d'Alene River. There are a number of potential sources of mining waste in Segment 3, which, as in Segment 1, have had some removals of mining waste. Also like Segment 1, some removals from BLM land did not include adjacent private land, and waste remains in place with possible or ongoing migration from erosion to the Creek. Concentrations of dissolved metals are lower in Segment 3 of Pine Creek than they are in Segment 1, and loading from Segment 3 of Pine Creek to the South Fork Coeur d'Alene river is about the same as loading to the upper end of Segment 3.

In Pine Creek, a higher fraction of the metals load, especially zinc, is in particulate form during high flows. This suggests that erosion and movement of particles is a significant process in Pine Creek, with harmful discharges of dissolved metals occurring mainly in Segment 1.

2.2.7 Prichard Creek

Prichard Creek is divided into three segments in the CSM (Table 2.1-1). Segment 1, Prichard Creek above the Paragon mill site, has few potential source areas (Appendix I) and little indication of metals contamination. Segment 2, Bear Gulch, also has few potential source areas (Appendix I), but slightly elevated levels of dissolved lead have been observed in the lower part of Bear Gulch.

Segment 3 of Prichard Creek, Prichard Creek below the Paragon mill site, has numerous potential source areas (Appendix I). Concentrations of dissolved metals at times approach or slightly exceed the ambient water quality criteria at the downstream end of Segment 3 (location NF033). Loading, which is slightly over 10 pounds of zinc per day, is substantially diluted by the time flows reach the North Fork Coeur d'Alene River.

2.2.8 Upper South Fork of the Coeur d'Alene River

Only one segment was assigned to the Upper South Fork of the Coeur d'Alene River (Upper South Fork) in the CSM (Table 2.1-1). There are numerous potential sources in Segment 1, Upper South Fork (Appendix I). Concentrations of dissolved metals exceed the ambient water quality criteria in the lower reaches and some tributaries of the Upper South Fork, but aquatic life, including fish, is present. Fish occur at relatively high abundances at the lower end of the segment, just above the confluence with Canyon Creek. It is possible that the extremely high concentrations of metals discharged from Canyon Creek are a chemical barrier to fish attempting to move downstream.

2.2.9 Upper North Fork of the Coeur d'Alene River

The Upper North Fork of the Coeur d'Alene River was included in the CSM primarily for use as a reference area. Except for Beaver, Eagle, and Prichard Creeks there are no likely potential source areas in the Upper North Fork, and results of water sampling do not indicate elevated levels of metals.

2.3 CSM UNIT 2, MIDGRADIENT WATERSHEDS

The mid-gradient watersheds were grouped on the basis of both size and gradient. Parts of three watersheds are included in CSM Unit 2 as described below. The Preliminary Process Models for CSM Unit 2 (Figure 2.3-1) are very similar to those for CSM Unit 1. There are numerous potential source areas in CSM Unit 2. While mine dumps and mill sites are important, the mining wastes deposited in the floodplain become the more important source of metal loading.

CSM Unit 2 is also the location of some of the larger physical disturbances that have resulted from human use of the Coeur d'Alene basin. These include the towns of Wallace and Kellogg, several smaller communities, railroads (now closed and being converted to trails), the Kellogg Airport, and Interstate 90 (I-90), which runs through the three segments also affected by mining waste. Many of the constructed facilities, including railroads, and roadways including I-90, were constructed using mining waste as fill, and in many instances were built over previously deposited mining wastes in the floodplain. To accommodate the infrastructure, and to make room for storing and disposing of mining wastes in the floodplain, the channel of the South Fork Coeur d'Alene River has been moved, channelized, armored, and otherwise altered, with only a few reaches still resembling a natural river.

CSM Unit 2 receives the input of about 1,000 pounds per day of zinc from upstream, mainly from Canyon and Ninemile Creeks, with some also from the Upper South Fork. During high flows, substantial amounts of dissolved and particulate lead and cadmium are also transported into CSM Unit 2.

The river valley is wide enough through most of CSM Unit 2 to accommodate varying amounts of groundwater flow. In two basins, described further below, exchanges of surface and groundwater are important processes for adding dissolved metals (mainly zinc and cadmium) to the South Fork.

Substantial parts of CSM Unit 2, including upland hillsides and residential and public areas, have also been affected by past metals emissions from the lead smelter at Smelterville in Segment 2. Remedial actions are in progress within the 21-square-mile Bunker Hill Superfund site from Kellog to Smelterville.

2.3.1 Segment 1, South Fork Coeur d'Alene River

Segment 1 of CSM Unit 2 is the South Fork from the mouth of Canyon Creek to Elizabeth Park (Table 2.1-1). There are numerous primary and secondary potential sources of mining waste and metals in segment 1 of CSM Unit 2 (Appendix I). Important sources are noted in the nature and extent of contamination section for each segment. Many of the primary source areas are on tributary gulches, but some including the Hercules mill site are located along the valley of the South Fork. Osburn Flats is the location of a former tailings impoundment on the South Fork. Surface water in the river is lost to ground water in the upper part of Osburn Flats. Return flows of groundwater in the lower part of Osburn Flats are sufficiently enriched in zinc to cause exceedance of the ambient water quality criteria in the South Fork absent any input from upstream. In all about 400 to 1,300 pounds of dissolved zinc per day, and lesser amounts of cadmium and lead, enter the South Fork as it passes through Segment 1 of CSM Unit 2, roughly doubling the load of zinc.

2.3.2 Segment 2, South Fork Coeur d'Alene River

Segment 2 of CSM Unit 2 is the South Fork from Elizabeth Park to the confluence of the South Fork with the North Fork. Most of Segment 2 is adjacent to the Bunker Hill Superfund Site (BHSS) and may be improved by ongoing remedial actions. For the purpose of this RI, the primary interest is the ongoing loading of metals that occurs in Segment 2 of CSM Unit 2, mainly by exchanges of surface water and groundwater and discharges of contaminated groundwater from beneath the BHSS in the vicinity of the Central Impoundment Area (CIA) and Smelterville. Note that the ROD for the Bunker Hill Superfund Site does not address the South Fork of the Coeur d'Alene River. Measurements taken during sampling for this RI, and previously, indicate that the zinc and other metals loads roughly double as the South Fork passes through Segment 2 of CSM Unit 2. The ultimate effect of the large amount of remedial work at the CIA, Smelterville, and along the South Fork through this segment is not presently known, and while removals of mining waste from Smelterville Flats to the CIA and capping with designed drainage for the CIA should reduce loading of metals to the South Fork, the groundwater interactions have not been explicitly defined, and large amounts of mining wastes remain in contact with groundwater. In addition, sizeable metals loads still enter the South Fork in surface water from Government Creek and Milo Creek. Within Segment 2 of CSM Unit 2, there are two recognized groundwater aquifers: an upper aquifer that exchanges freely with the South Fork and a lower aquifer that is separated from the upper aquifer by a clay layer deposited during a former high stand of Coeur d'Alene Lake. The clay layer thins toward the upstream part of Segment 2, and might be absent above Kellogg. This might be important because it suggests that metals-contaminated groundwater could enter the lower aquifer above Kellogg.

2.3.3 Segment 3, North Fork Coeur d'Alene River

The North Fork Coeur d'Alene River (North Fork) from Prichard to the confluence with the South Fork is Segment 3 of CSM Unit 2 (Table 2.1-1). The North Fork has not been significantly affected by releases of metals from mining wastes, but is a significant source of clean water and sediment to the Coeur d'Alene River. Some portions of the North Fork and its tributaries are also suitable reference areas for watersheds and segments in the South Fork watershed because they have been subjected to similar non-mining-related disturbances.

2.3.4 Segment 4, Main Stem Coeur d'Alene River

Segment 4 of CSM Unit 1 is the Coeur d'Alene River from the confluence of the North Fork and South Fork to the last (downstream) gravel riffle at the point where the old highway bridge crosses the river upstream from I-90 (Table 2.1-1). This segment was included in CSM Unit 2 because it is comprised of pools and riffles, with a sand and gravel bottom like much of the rest of CSM Unit 2. There are no known significant primary sources of mining wastes in this segment (Appendix I), but numerous deposits of alluvium contaminated by mining wastes. There is some loading of dissolved metals to Segment 4 at times because of exchanges of surface water and groundwater, but loading is considerably less than in Segments 1 and 2 of CSM Unit 2. Alluvial deposits containing mining wastes are mobilized during high flows and transported downstream as bed load and suspended load.

2.4 CSM UNIT 3, LOWER COEUR D'ALENE RIVER

CSM Unit 3 is the entire lower valley of the Coeur d'Alene River from the last riffle at Cataldo to the mouth of the river at Harrison. It includes the entire floodplain, lateral lakes, and associated wetlands. In CSM Unit 3, the river form is low gradient with meanders, but the meanders are not very active because of natural and enhanced levees in many places, and armoring to protect roads, bridges, and railroad beds in a few places. The lateral lakes are an unusual feature of CSM Unit 3 that is related to how Coeur d'Alene Lake was formed. Coeur d'Alene Lake was formed when massive glacial floods deposited debris in the valley of the Spokane River, blocking the valley now occupied by Coeur d'Alene Lake. Materials eroded from the surrounding mountains in the upper valley has, over time, filled part of the lake. The process of deposition are still evident throughout the lower Coeur d'Alene basin. The initial stages of formation of lateral lakes are still occurring at Harrison, where relatively recent levees extend into Coeur d'Alene Lake; the later stages are represented by some of the wetlands and agricultural areas where filling of the lateral lakes is essentially complete. Current water levels in CSM Unit 3 are held artificially high by the dam on the Spokane River at Post Falls, which raises the elevation of Coeur d'Alene Lake during the summer months when water levels would naturally be lower.

A single Preliminary Process Model was developed for CSM Unit 3 (Figure 2.4-1). Notations on the diagram show which of the various release mechanisms, affected media, and secondary sources apply to the respective six segments. The six segments in CSM Unit 3 were established because of differences in fluvial processes within the unit, but more because of varying use and exposure of wildlife, particularly waterfowl, within CSM Unit 3. A third reason for the six segments was a desire to have segments with a smaller geographic size than the entire unit to facilitate subsequent analysis. The six segments are combined in this discussion.

Except for the Union Pacific Railroad bed, which is addressed under an agreement among the Railroad, the State of Idaho, the U.S. Federal Government, and the Coeur d'Alene Tribe, there are no known significant primary source areas in CSM Unit 3 (MFG 1999). Contaminated soils and sediments occur throughout the unit, with levels of contamination and depth of contamination generally being higher near the river and in lateral lakes where flows from the river enter during floods. Sampling locations for surface water in CSM Unit 3 did not match the segment boundaries, so metals loading has not been determined at the segment level, but has instead been determined at the following three locations: Cataldo at the upper end of the segment, Rose Lake in Segment 3, and near the downstream end of CSM Unit 3 at Harrison in Segment 6. Sampling and analysis of water and calculations of metals load at those locations has been done by the U.S Geological Survey (USGS). Loads of metals carried by the Coeur d'Alene River through CSM Unit 3 have been calculated over several years by USGS, with both the magnitude of loading and the geographic pattern of loading varying from year to year. Loading is discussed in more detail in the Nature and Extent of Contamination section for each watershed.

There are several studies that indicate groundwater in CSM Unit 3 is contaminated with metals and that the water-bearing formations are composed of relatively fine sediments which slow the flow of groundwater. Loading calculations indicate that either contaminated groundwater or dissolution of metals from mining wastes in the banks and bed of the river is the source of metal loading in the river.

The groundwater pathway for dissolved metals entering the Coeur d'Alene River in CSM Unit 3 is not known. The investigation of the hydrogeology of CSM Unit 3 has been sparse and limited to three particular areas: the dredge spoils at Cataldo in Segment 1, an area around Killarney Lake in Segment 2, and the delta of the Coeur d'Alene River at Harrison in Segment 6. Given the nature of the depositional processes in CSM Unit 3, it is possible that one or more drowned and buried river channels exist with higher hydraulic conductivity than has been determined from past studies.

Concentrations of metals in surface water in CSM Unit 3 are lower than in the South Fork in CSM Unit 2 because of dilution by the larger North Fork. Concentrations of dissolved metals still commonly exceed ambient water quality criteria, but aquatic life (including resident and migrating fish) is present in CSM Unit 3.

The thousands of acres of wetlands and lakes in CSM Unit 3 are an attractant for waterfowl, and extensive areas are managed by the State of Idaho for waterfowl production and recreational hunting. Waterfowl have been, and continue to be, poisoned by consuming lead-contaminated sediment during feeding, as are other types of wildlife. Additional areas are farmed, mainly for hay and grazing, but are also used extensively by waterfowl and other wildlife (e.g., raptors) during seasonal flood events.

Contamination of surface soils and sediments at distance from the river has been caused by periodic flooding of the Coeur d'Alene River. In general, levels of contamination are lower, or sometimes absent, in places protected from direct flooding. This includes large areas south of the bed of the (now closed) Union Pacific Railroad between Cataldo and Harrison.

Studies (summarized by Status 2000) have shown that lead in the sediment that causes mortality and other adverse health effects is the result of upstream mining activities. Although some lead is bioaccumulated by plants and other food-chain organisms, much of the poisoning is a result of incidental ingestion of sediment by wildlife.

2.5 CSM UNIT 4, COEUR D'ALENE LAKE

CSM Unit 4, Coeur d'Alene Lake, is divided into three segments in the CSM (Table 2.1-1). The Preliminary Process Model for Segment 2 (Figure 2.5-1) applies in varying degrees to all three segments. Except for fill for ballast for the Union Pacific Railroad, and local spills of ore and concentrates being transported to and from the Coeur d'Alene River basin, there are no primary source areas in CSM Unit 4. Clean material was reportedly used to build the levees for the railroad but contaminated material was used for the ballast into which the railroad tracks were laid. The Coeur d'Alene River is the overwhelmingly dominant source of metals to Coeur d'Alene Lake. Metals enter the lake from the river as dissolved metals, particulate metals on fine suspended solids, and as larger particles in bed load. It has been estimated by the USGS that approximately 75 million metric tons (49.7 million cubic yards) of metals-contaminated sediment reside on the bottom of Coeur d'Alene Lake. This includes the quantity of contaminated sediment in the delta of the Coeur d'Alene River which has been estimated at approximately 3 million cubic yards (Bookstrom 2001).

Nutrient input to Coeur d'Alene Lake has been raised as an issue with regard to release of metals from contaminated lakebed sediment. The St. Joe River was included as a component of CSM Unit 4 (Figure 2.1-1) to account for nutrient inputs. The trophic status (level of nutrient enrichment and phytoplankton production) of Coeur d'Alene Lake could change to the point where increased production of phytoplankton could cause reductions of oxygen levels in the deeper waters of the lake. This could allow the release of metals associated with oxyhydroxide precipitates found on the surface of the lake sediments.

Water entering the lake from the Coeur d'Alene River is often of a different temperature than the water in the lake. Depending on the differences in density caused by the different temperatures, the metals-contaminated plume might sink or float without completely mixing with lake water. According to studies by the USGS, a floating plume is the most common condition. When that happens during periods of high flow in the Coeur d'Alene River, dissolved metals and some metals-contaminated particulates are carried to the Spokane River at the north end of the lake without mixing completely with lake water.

The distribution of metals contamination in the sediment in deep water may reflect the different forms of the metals when they arrive at Coeur d'Alene Lake, or differential re-mobilization of metals from the sediment. Lead, which enters the lake mainly as particles, has higher concentrations near the delta at Harrison, although concentrations in excess of 2,000 mg/kg of sediment occur throughout the lake. Zinc and cadmium, which arrive mainly as dissolved metals, have lower concentrations in deep-water sediments near the delta than in deep-water sediments at the north end of the lake near Coeur d'Alene. Settling of zinc and cadmium to the bottom of the lake might depend on their first becoming adsorbed to or incorporated into particles, including phytoplankton and other organic matter, which then settle to the lake bottom.

The presence of metals mainly in dissolved or fine particulate forms has limited the accumulation of metals in sediment near shore or in shallow areas. Wave action and fluctuating lake levels winnow the fine sediments with which the metals are associated away from shallow water. An exception to this occurs at Harrison where deposition of either larger amounts of particles, or larger particles has resulted in elevated beach sediments.

A varying fraction of the metals entering Coeur d'Alene Lake are retained within the lake. Retention (input from the Coeur d'Alene River minus output by the Spokane River) of particulate metals is high, with up to 80 to 90 percent of the total lead being retained. Retention of dissolved metals entering the lake is lower and depends on the metals being converted to particulate form and settling to the sediment. Over part of 1999, about 80 percent of the dissolved zinc entering the lake exited via the Spokane River. Some metals that reach the sediment in particulate form are subsequently released in dissolved form, mainly by diffusion from the sediment to the overlying water. The export of dissolved metals by the Spokane river is the net result of the processes of transport of dissolved metals through the lake, particulate settling and diffusive release from the sediment, and "short-circuiting" the lake by floating plumes from the Coeur d'Alene River.

Concentrations of metals in the water of Coeur d'Alene Lake often exceed ambient water quality criteria, but not necessarily at all locations or even at all depths at any given location. The lake supports populations of aquatic life including several valued species of fish that provide recreational fishing based mainly on either planktonic food chains in open water, or littoral (near shore) food chains in shallow water.

2.5.1 Segment 1, Coeur d'Alene Lake South of Harrison

Segment 1 of CSM Unit 4, Coeur d'Alene Lake from Harrison south to the St. Joe River has some contaminated sediment at depth, but that is mainly limited to the northern third of the segment. Concentrations of metals in the water generally do not exceed the ambient water quality criteria. Some areas in the shallow extreme southern end of Segment 1 have been observed to have reduced concentrations of dissolved oxygen during the summer months.

2.5.2 Segment 2, Coeur d'Alene Lake From Harrison to the Spokane River at Coeur d'Alene

Segment 2 of CSM Unit 4 receives most of the metals input to the lake and has the largest amount of contaminated sediment. Concentrations of dissolved metals, notably lead and zinc, exceed the ambient water quality criteria more often in Segment 2 than in other parts of the lake.

2.5.3 Segment 3, Wolf Lodge Bay

Segment 3, Wolf Lodge Bay, is an arm of Coeur d'Alene Lake at the north end of the lake. There are several small mines in the Wolf Lodge Creek watershed, none of which has operated for many years. Deep sediment in Wolf Lodge Bay is contaminated with metals with decreasing concentrations toward the head of the bay. The gradient of contamination suggests that the main part of Coeur d'Alene Lake is the source of the metals, rather than the mines in the Wolf Lodge Creek Watershed.

2.6 CSM UNIT 5, SPOKANE RIVER

CSM Unit 5, the Spokane River, is divided into three segments based on political boundaries, a major dam, and the predominant morphology of the river Table 2.1-1). The Preliminary Process Models for the Spokane River (Figure 2.6-1) are simpler than the models for the upper basin because the Spokane River lacks primary sources of metals (mining-related sources), and therefore primary release mechanisms, and because the main mechanism for transport of metals is the flowing river. Minor sources of metals in the Spokane River likely include permitted discharges and non-point sources. CSM Unit 5 has other important features that are lacking from other CSM units: the Rathdrum Prairie aquifer, which is a critical water supply for the Spokane area and the presence of six hydroelectric dam facilities.

The Rathdrum Prairie aquifer receives about one-third of its subsurface flow from Coeur d'Alene Lake, and two-thirds from the Purcell Trench, a flood-debris-filled valley that receives groundwater flow from Lake Pend'Oreille to the north. Sampling of groundwater in the vicinity of Coeur d'Alene has indicated that dissolved metals present in the water of Coeur d'Alene Lake do not travel far into the Rathdrum Prairie aquifer, but the Spokane River exchanges water with the aquifer through alternating losing and gaining reaches as it passes through the Spokane area.

Metals discharged from Coeur d'Alene Lake in dissolved and particulate form are carried down the Spokane River. During high flows, concentrations of dissolved lead and zinc exceed the ambient water quality criteria (coincident with State of Washington standards) in the Spokane River. Concentrations of dissolved metals decrease with distance down the Spokane River during lower flows, in part because of exchange of water between the river and the aquifer, but also perhaps in part because of precipitation caused by increased alkalinity discharged from the aquifer. The alkalinity added by the aquifer reduces the toxicity of the remaining metals.

Fine-grained suspended sediment in the Spokane River is contaminated with arsenic, lead, and zinc, with generally decreasing concentrations from upstream to downstream. Suspended sediment is transported through the reservoirs; however, considerable quantities of sediment are deposited in reservoirs throughout the length of the Spokane River. The largest accumulation of sediment exists in the Long Lake reservoir, with most of the sediment currently coming from Hangman Creek.

The Spokane River supports a fishery for rainbow trout based in part on natural reproduction and in part on hatchery-stocked fish. However, mortality studies indicate an annual mortality rate of about 70 percent, with only about 10 percent accounted for by fishing (Bennett and Underwood 1988). Other mortality was attributed to post-spawning adult mortality, high zinc concentrations, elevated summer temperatures, and low summer flows. Important spawning and rearing areas are in the upper part of the Spokane River where metals concentrations are highest, and alkalinity is lowest, suggesting that metals toxicity could be contributing to the excess mortality of trout.

2.6.1 Segment 1, Spokane River From Coeur d'Alene Lake to the State Line

Segment 1 of CSM Unit 5 includes two reaches: one from Coeur d'Alene Lake at Coeur d'Alene to Post Falls Dam, and a short reach from below Post Falls Dam to the state line. The reach above Post Falls is artificially regulated by the Post Falls Dam. During high flows, the gates at the dam are opened and water levels over parts of the reach, and upstream into Coeur d'Alene Lake, are regulated by the natural channel. The reach from Post Falls Dam to the State line is free-flowing. Metals concentrations and flows measured at Post Falls Dam by the USGS are the basis for estimating discharges of metals from Coeur d'Alene Lake.

2.6.2 Segment 2, Spokane River From the State Line to Long Lake

Segment 2 of CSM Unit 5 contains both free-flowing reaches and backwaters behind low dams. The backwater areas are places where the greatest volumes of fine-grained sediments are deposited. Exchanges of water between the river and the aquifer occur throughout Segment 2. Concentrations of dissolved zinc exceed ambient water quality criteria over portions of this reach through most of the year, and concentrations of dissolved lead exceed the ambient water quality criteria during high flows. Fine-grained sediment in natural depositional areas along free-flowing reaches, including places used for water-contact recreation, has concentrations of lead above background and in some locations above human health screening levels. The main depositional areas are behind Upriver Dam, behind the low dam at Spokane Falls in Spokane, and behind Nine Mile Dam downstream from Spokane. Pockets of fine-grained sediments are located behind boulders and on small beaches throughout the segment.

The backwater areas behind the dams contain small habitat areas such as riparian wetlands, that are otherwise not common along the Spokane River.

Hangman Creek enters the Spokane River just west of downtown Spokane. The flow and water dilution contributed by Hangman Creek is typically small, but substantial amounts of sediment low in metals are discharged during high spring flows, resulting in some dilution of metals concentrations at its confluence with the Spokane River.

2.6.3 Segment 3, Long Lake and the Spokane Arm of Lake Roosevelt

Segment 3 of CSM Unit 5 consists mainly of Long Lake, a reservoir on the Spokane River, and the Spokane Arm of Lake Roosevelt. The Little Spokane River enters the Spokane River near the upper boundary of Segment 3. Concentrations of dissolved metals in the water of Segment 3 generally do not exceed ambient water quality criteria. Concentrations of lead in the sediment of Long Lake are slightly elevated. Concentrations of zinc in Long Lake sediments are substantially elevated above the background level. Zinc in sediment samples collected from the Spokane arm of Lake Roosevelt is intermittently elevated above the background level.

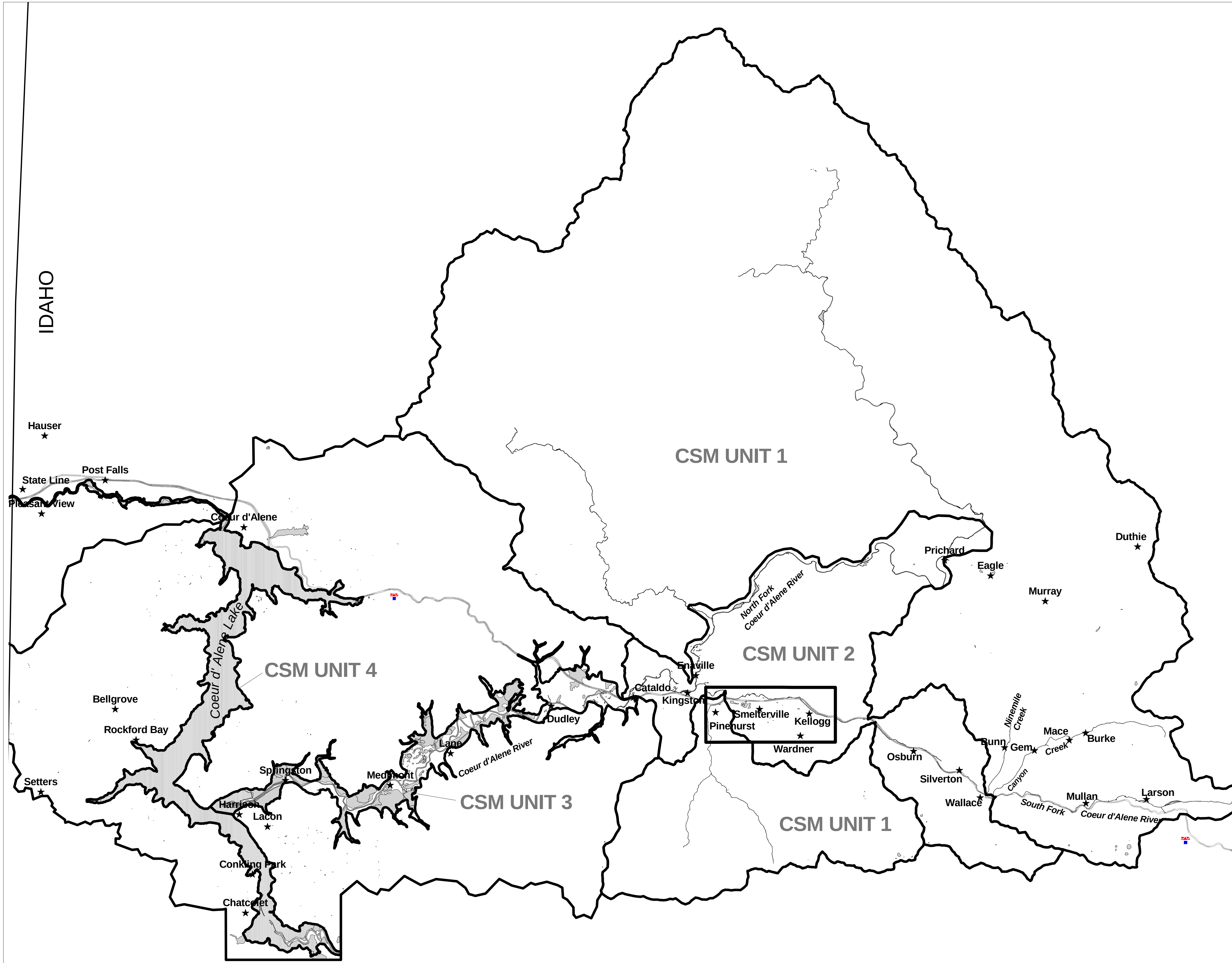
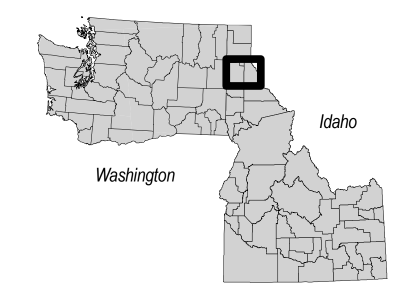


Figure 2.1-1
CSM Unit Boundaries
CSM Units 1, 2, 3, and 4

LEGEND

- ★ City
- CSM Unit Boundary
- Bunker Hill Site Boundary
- Interstate 90
- Lakes and Rivers



Location Map

NOTES

1) Base map coverages obtained from the Coeur d' Alene Tribe, URS Greiner Inc., CH2M HILL, and the Bureau of Land Management.

SCALE 1:400,000

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7/18/2001

This map is based on Idaho State Plane Coordinates West Zone, North American Datum 1983.

Date of Plot: July 18, 2001

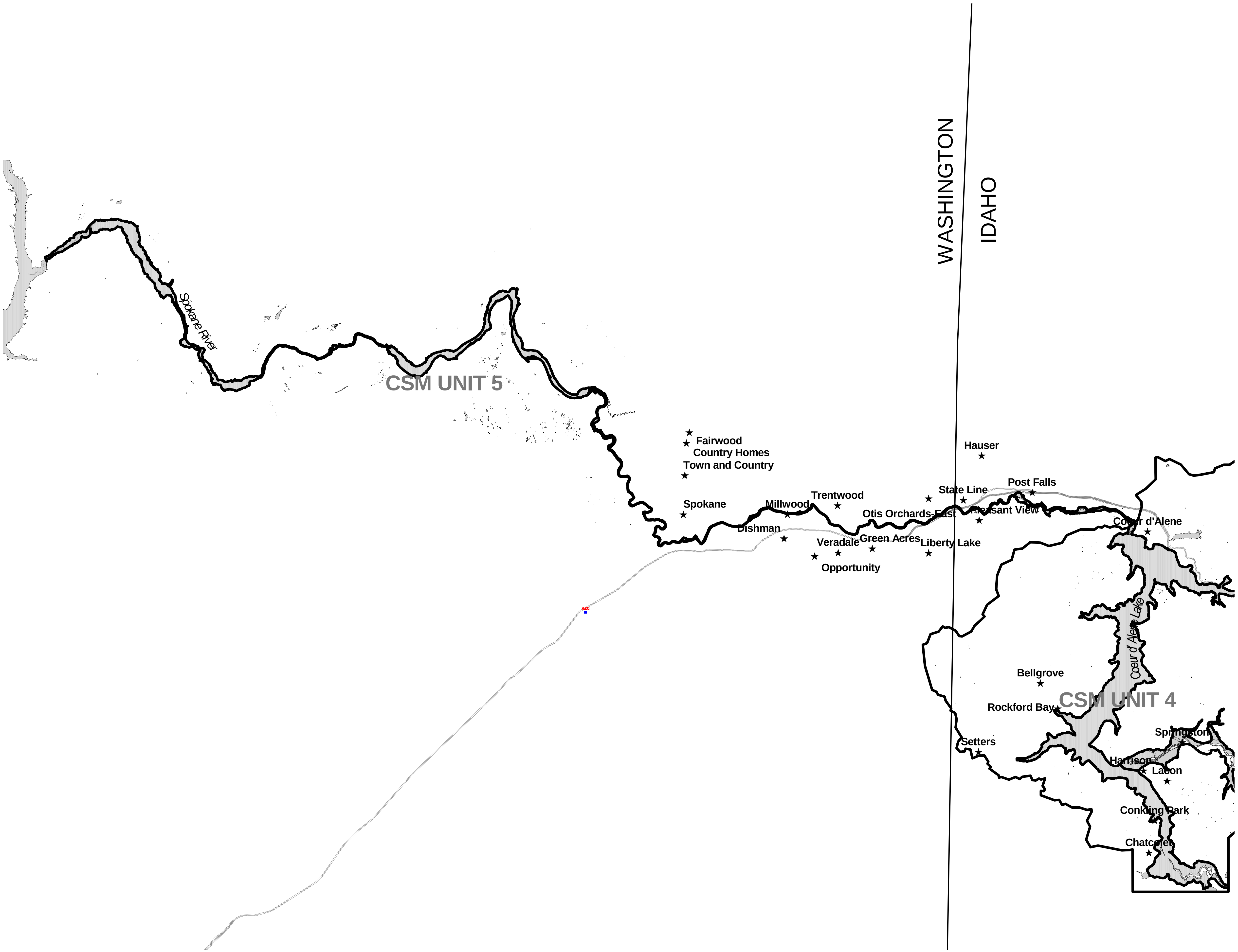

Figure 2.1-2
CSM Unit Boundaries
CSM Units 4 and 5

LEGEND

- ★ City
- CSM Unit
- Interstate 90
- Lakes and Rivers

Location Map

NOTES

1) Base map coverages obtained from the Coeur d' Alene Tribe, URS Greiner Inc., CH2M HILL, and the Bureau of Land Management.

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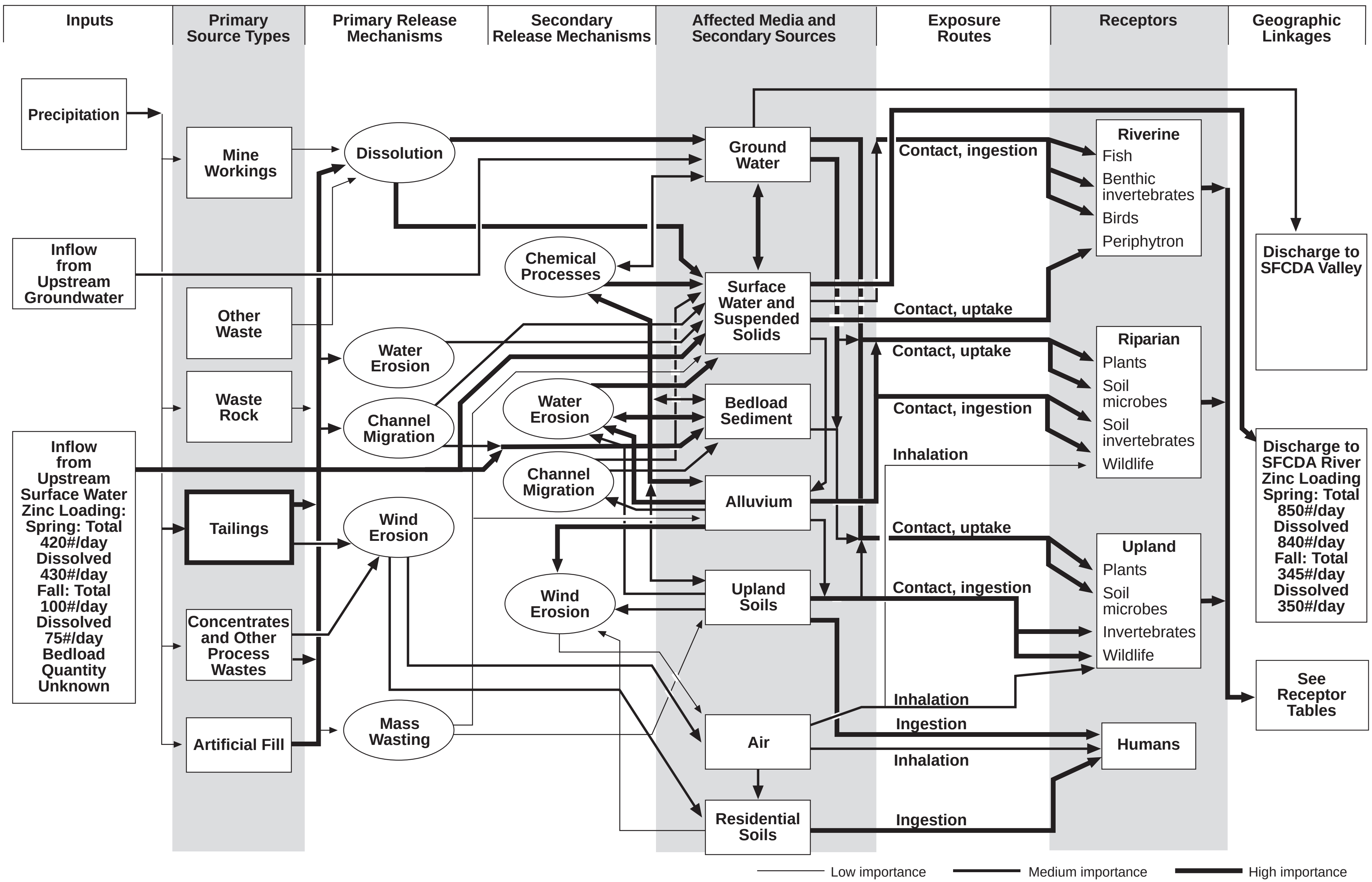

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Figure 2.2-1
CSM Unit 1, Canyon Creek Watershed, Segment 5
Process Model

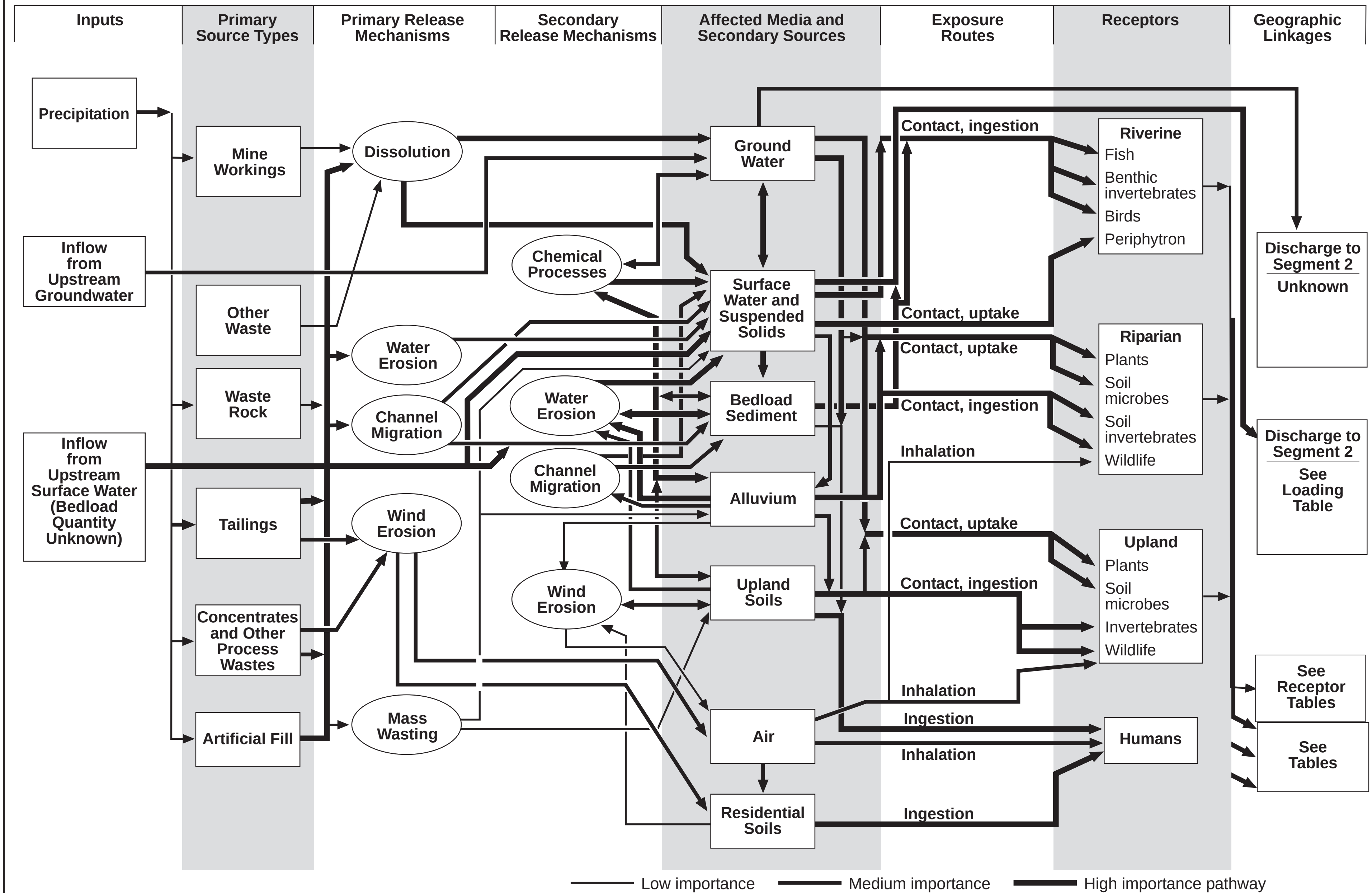

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Figure 2.3-1
CSM Unit 2, Mid-Gradient Streams, Segment 1, South Fork of Coeur d'Alene River
Process Model

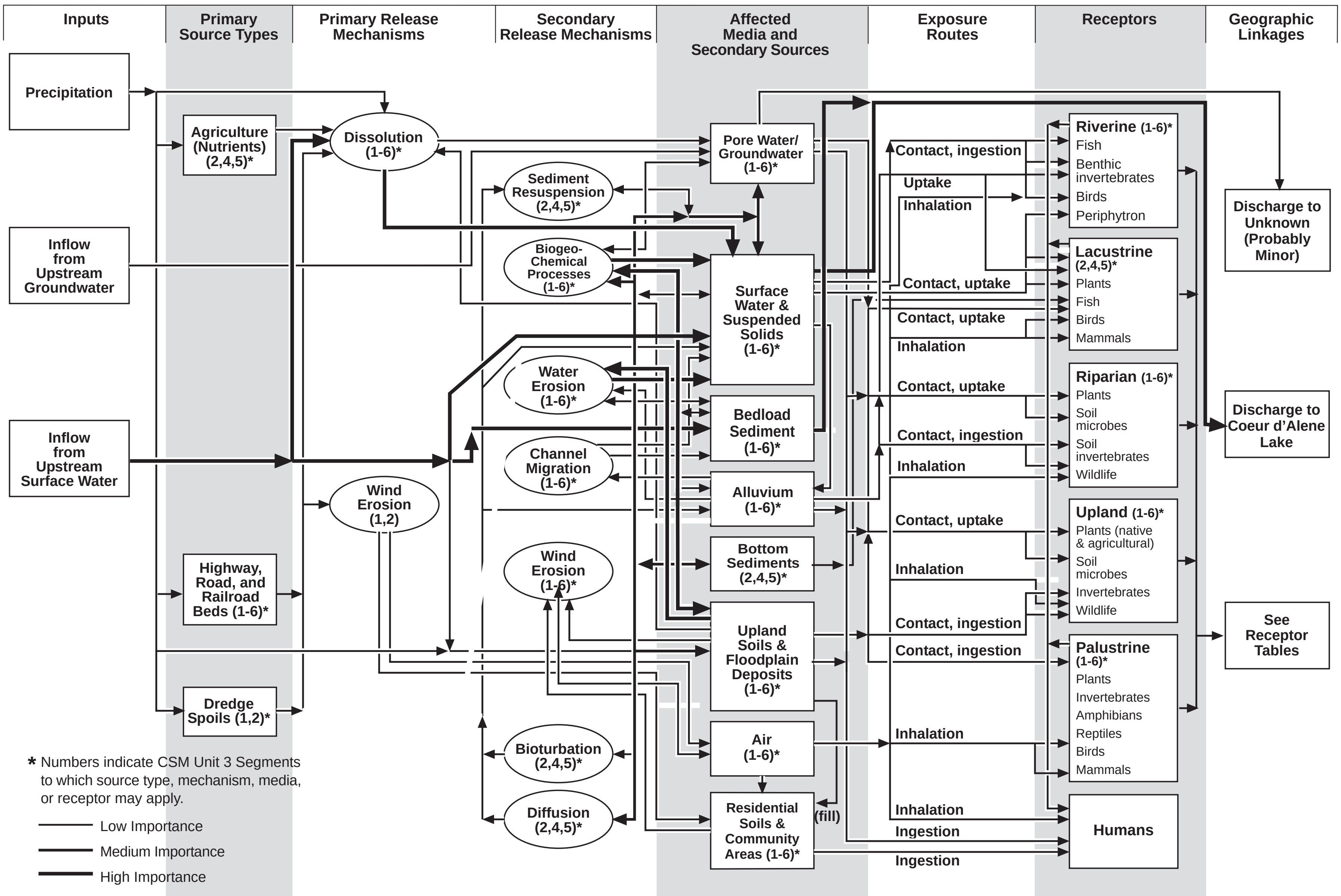

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Figure 2.4-1
CSM Unit 3, Low Gradient Stream Process Model, All (6) Segments
(Old Highway Bridge at Cataldo to Coeur d'Alene Lake)

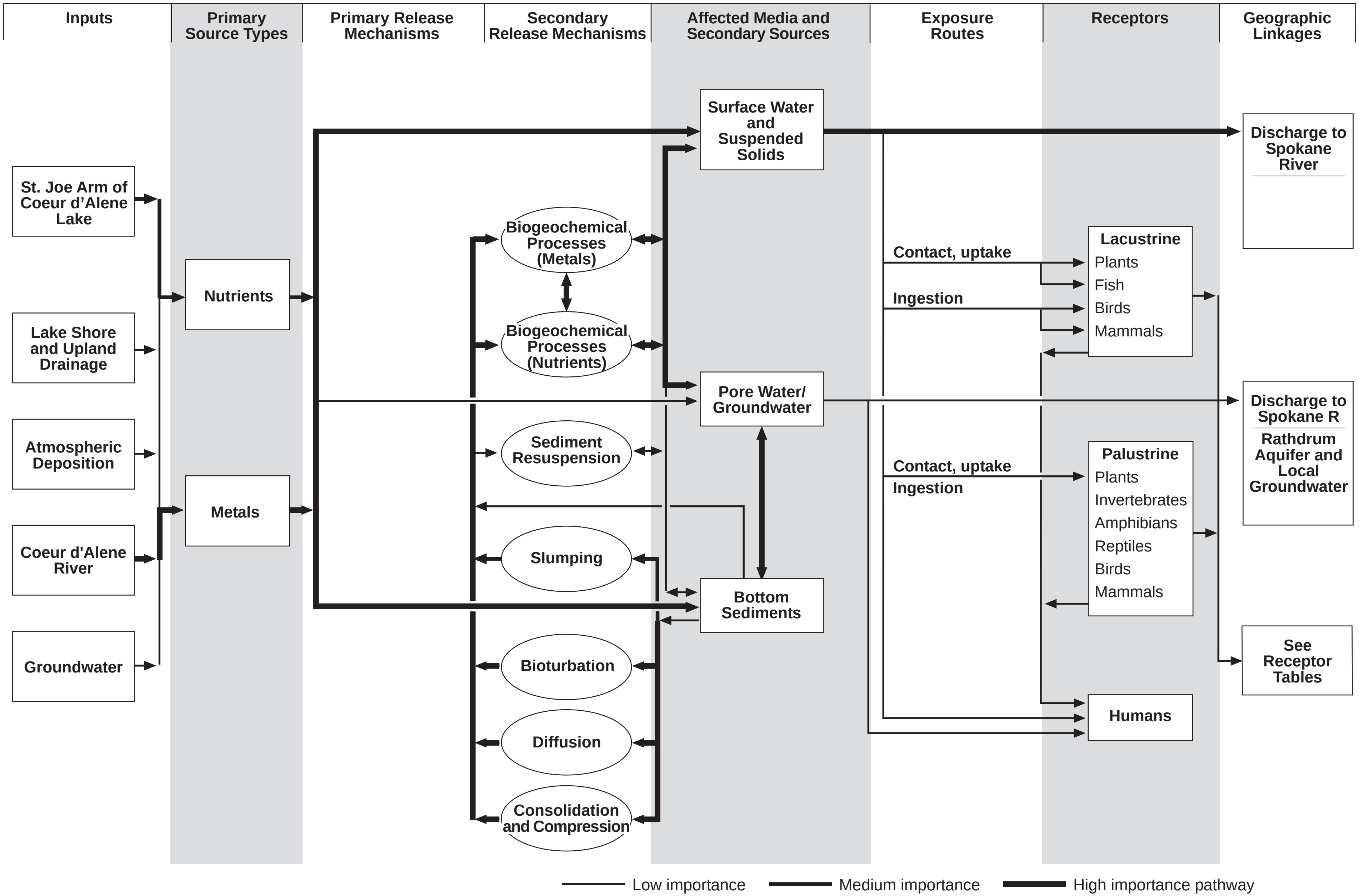

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Figure 2.5-1
CSM Unit 4, Coeur d'Alene Lake, Segment 2
Process Model

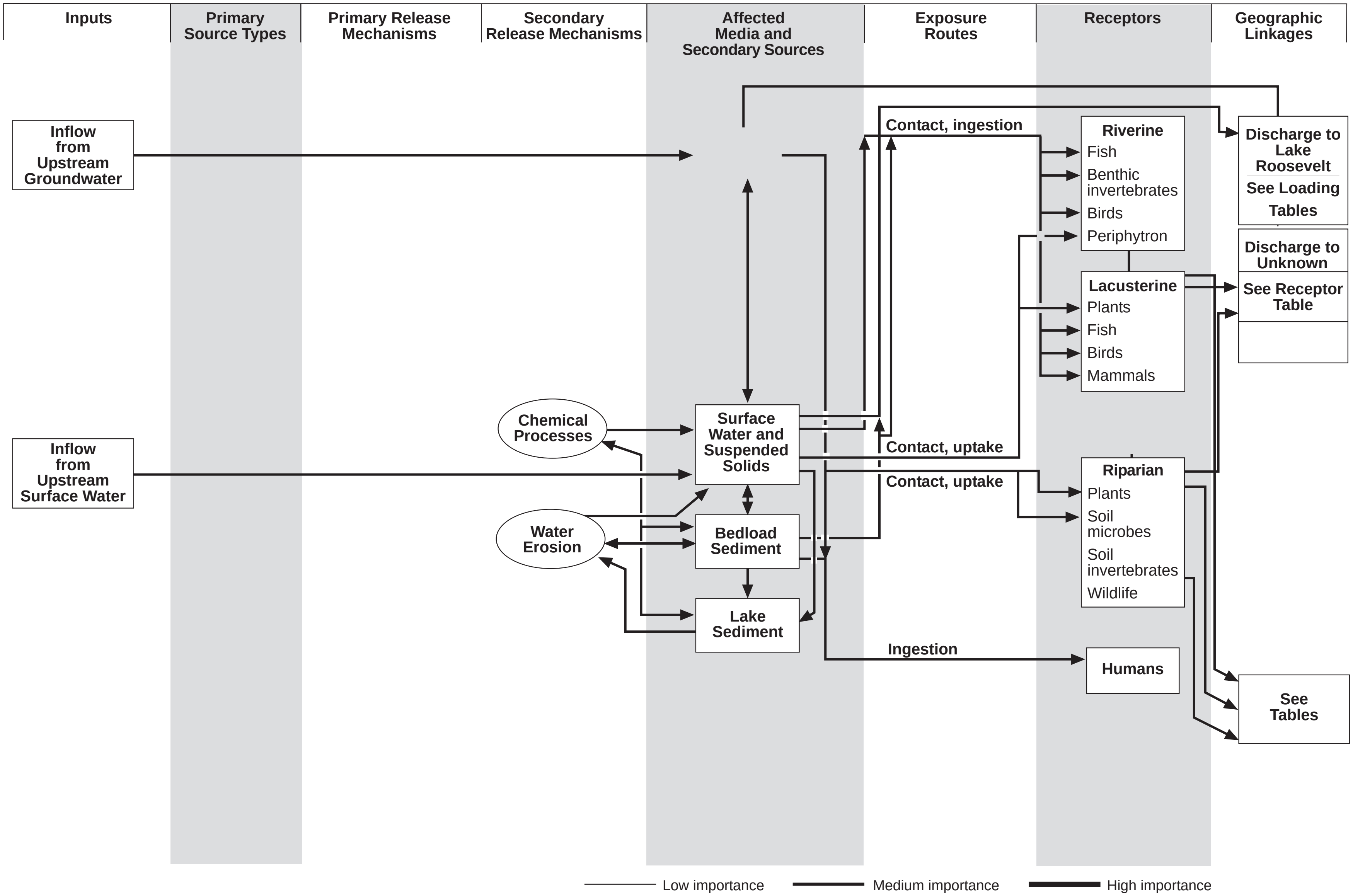

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Figure 2.6-1
CSM Unit 5, Spokane River, Segment 3
Process Model

Table 2.1-1
CSM Units, Watersheds, Segments, and Segment Descriptions

CSMUnit	Watershed	SegmentName	Segment Description	CSMSegID
CSM Unit 01, Upper Watersheds	Beaver Creek	BvrCrkSeg01	Beaver Creek Segment 1: Entire watershed	2
CSM Unit 01, Upper Watersheds	Big Creek	BigCrkSeg01	Big Creek Segment 1: Big Creek Above East Fork Tributary	1
CSM Unit 01, Upper Watersheds	Big Creek	BigCrkSeg02	Big Creek Segment 2: Big Creek East Fork	38
CSM Unit 01, Upper Watersheds	Big Creek	BigCrkSeg03	Big Creek Segment 3: Big Creek West Fork	39
CSM Unit 01, Upper Watersheds	Big Creek	BigCrkSeg04	Big Creek Segment 4: Big Creek Below East Fork Tributary	40
CSM Unit 01, Upper Watersheds	Canyon Creek	CCSeg01	Canyon Creek Segment 1: Upper Canyon Creek above the Hecla Intake	3
CSM Unit 01, Upper Watersheds	Canyon Creek	CCSeg02	Canyon Creek Segment 2: Hecla Intake to confluence w/ Gorge Gulch and O'Neil Gulch	4
CSM Unit 01, Upper Watersheds	Canyon Creek	CCSeg03	Canyon Creek Segment 3: Gorge Gulch	5
CSM Unit 01, Upper Watersheds	Canyon Creek	CCSeg04	Canyon Creek Segment 4: Gorge Gulch to Woodland Park	6
CSM Unit 01, Upper Watersheds	Canyon Creek	CCSeg05	Canyon Creek Segment 5: Woodland Park to confluence w/ South Fork Coeur d'Alene River	7
CSM Unit 01, Upper Watersheds	Moon Creek	MoonCrkSeg01	Moon Creek Segment 1: West Fork of Moon Creek	17
CSM Unit 01, Upper Watersheds	Moon Creek	MoonCrkSeg02	Moon Creek Segment 2: Moon Creek watershed except West Fork of Moon Creek	41

Table 2.1-1 (Continued)
CSM Units, Watersheds, Segments, and Segment Descriptions

CSMUnit	Watershed	SegmentName	Segment Description	CSMSegID
CSM Unit 01, Upper Watersheds	Ninemile Creek	NMSeg01	Ninemile Creek Segment 1: Upper East Fork Ninemile Creek above Interstate Millsite	18
CSM Unit 01, Upper Watersheds	Ninemile Creek	NMSeg02	Ninemile Creek Segment 2: East Fork Ninemile Creek from Interstate Millsite to confluence with West Fork Ninemile Creek	19
CSM Unit 01, Upper Watersheds	Ninemile Creek	NMSeg03	Ninemile Creek Segment 3: West Fork Ninemile Creek	20
CSM Unit 01, Upper Watersheds	Ninemile Creek	NMSeg04	Ninemile Creek Segment 4: Lower Ninemile Creek from confluence with West Fork to Mouth	21
CSM Unit 01, Upper Watersheds	Pine Creek	PineCrkSeg01	Pine Creek Segment 1: East Fork and tributaries.	24
CSM Unit 01, Upper Watersheds	Pine Creek	PineCrkSeg02	Pine Creek Segment 2: Upper Pine Creek and tributaries.	25
CSM Unit 01, Upper Watersheds	Pine Creek	PineCrkSeg03	Pine Creek Segment 3: Pine Creek from East Fork tributary to mouth.	26
CSM Unit 01, Upper Watersheds	Prichard Creek	PrichCrkSeg01	Prichard Creek Segment 1: Prichard Creek above Paragon Millsites	27
CSM Unit 01, Upper Watersheds	Prichard Creek	PrichCrkSeg02	Prichard Creek Segment 2: Bear Gulch Tributary of Prichard Creek	42
CSM Unit 01, Upper Watersheds	Prichard Creek	PrichCrkSeg03	Prichard Creek Segment 3: Prichard Creek below Paragon Gulch including Paragon Millsites and Paragon Tailings	43
CSM Unit 01, Upper Watersheds	Upper North Fork	NrthFrkSeg01	North Fork Segment 1: North Fork Coeur d'Alene River above Prichard.	22
CSM Unit 01, Upper Watersheds	Upper South Fork	UpperSFCDRSeg01	Upper South Fork Coeur d'Alene River: Entire watershed.	28

Table 2.1-1 (Continued)
CSM Units, Watersheds, Segments, and Segment Descriptions

CSMUnit	Watershed	SegmentName	Segment Description	CSMSegID
CSM Unit 02, Midgradient Watersheds	Main Stem Coeur d'Alene River Above Cataldo	MidGradSeg04	Midgradient Streams Segment 04: South Fork Coeur d'Alene River from Enaville to Cataldo. - Coeur d'Alene River below confluence of North and South Forks of Coeur d'Alene River to the old Cataldo Bridge.	16
CSM Unit 02, Midgradient Watersheds	North Fork	MidGradSeg03	Midgradient Streams Segment 03: North Fork Coeur d'Alene River from Prichard to Enaville. - North Fork from mouth of Prichard Creek to confluence at Enaville	15
CSM Unit 02, Midgradient Watersheds	South Fork	MidGradSeg01	South Fork Segment 01: South Fork Coeur d'Alene River from Canyon Creek to Kellogg. - Where Canyon Creek enters South Fork Creek to Elizabeth Park where Elk Creek enters at bridge from I-90 exit to Elizabeth Park	13
CSM Unit 02, Midgradient Watersheds	South Fork	MidGradSeg02	South Fork Segment 02: South Fork Coeur d'Alene River from Kellogg to Enaville. - Elizabeth Park through superfund site to Enaville at confluence with North Fork	14
CSM Unit 03, Lower Coeur d'Alene River Floodplain	Coeur d'Alene River Below Cataldo	LCDRSeg01	Lower Coeur d'Alene River Segment 01: Old Cataldo Bridge to Cataldo boat landing below Cataldo Mission	12
CSM Unit 03, Lower Coeur d'Alene River Floodplain	Coeur d'Alene River Below Cataldo	LCDRSeg02	Lower Coeur d'Alene River Segment 02: Cataldo Boat landing to Killarney Lake Road	29
CSM Unit 03, Lower Coeur d'Alene River Floodplain	Coeur d'Alene River Below Cataldo	LCDRSeg03	Lower Coeur d'Alene River Segment 03: Killarney Lake Road to Killarney Lake Canal	30
CSM Unit 03, Lower Coeur d'Alene River Floodplain	Coeur d'Alene River Below Cataldo	LCDRSeg04	Lower Coeur d'Alene River Segment 04: Killarney Lake Canal to upper end of Bear Marsh, including Killarney Lake	31
CSM Unit 03, Lower Coeur d'Alene River Floodplain	Coeur d'Alene River Below Cataldo	LCDRSeg05	Lower Coeur d'Alene River Segment 05: Upper end Bear Marsh to Harrison Bridge	32

Table 2.1-1 (Continued)
CSM Units, Watersheds, Segments, and Segment Descriptions

CSMUnit	Watershed	SegmentName	Segment Description	CSMSegID
CSM Unit 03, Lower Coeur d'Alene River Floodplain	Coeur d'Alene River Below Cataldo	LCDRSeg06	Lower Coeur d'Alene River Segment 06: Harrison Bridge to Coeur d'Alene Lake	33
CSM Unit 04, Coeur d'Alene Lake	Coeur d'Alene Lake	CDALakeSeg01	Coeur d'Alene Lake Segment 1: South of Harrison	11
CSM Unit 04, Coeur d'Alene Lake	Coeur d'Alene Lake	CDALakeSeg02	Coeur d'Alene Lake Segment 2: Harrison to Spokane River at Coeur d'Alene	34
CSM Unit 04, Coeur d'Alene Lake	Coeur d'Alene Lake	CDALakeSeg03	Coeur d'Alene Lake Segment 3: Wolf Lodge Bay	35
CSM Unit 05, Spokane River	Spokane River	SpokaneRSeg01	Spokane River Segment 1: Coeur d'Alene Lake at Coeur d'Alene to State Line	8
CSM Unit 05, Spokane River	Spokane River	SpokaneRSeg02	Spokane River Segment 2: State Line to Long Lake	9
CSM Unit 05, Spokane River	Spokane River	SpokaneRSeg03	Spokane River Segment 03: Long Lake and Lake Roosevelt	10

3.0 PHYSICAL SETTING

As discussed in Section 2 (CSM), mining-related impacts have been identified in many of the watersheds. In particular, Canyon Creek, Ninemile Creek, Pine Creek, the South Fork, Main Stem and the Coeur d'Alene Lake have the greatest impacts both in aspects of human health and the ecosystem.

This section includes descriptions of regional physical information and is intended to give an overview of physical processes operating within the basin. Descriptions of regional meteorology, geology, geochemistry, hydrogeology, hydrology, ecology, and demographics are included in this section. Watershed-specific details of these processes are discussed, as necessary, for individual watersheds in Parts 2 through 6.

3.1 METEOROLOGY

This section discusses meteorological aspects of the project area. Climate, temperature, precipitation, and wind patterns are addressed. As previously described, the project area has been divided into five areas. These are described in the CSM and referred to here as CSM Units 1 through 5. In general, this section will discuss meteorology by CSM Unit. CSM Units 1 and 2 will be discussed together because the Coeur d'Alene mining district ("the district") occupies most of both units.

3.1.1 CSM Units 1 and 2

CSM Units 1 and 2 are located in the climate region known as "highland climates," which is characterized by wide variations in temperature and precipitation due to elevation differences between valleys and adjacent mountains (Gedzelman 1980). Wide variations in snowfall volume also accompany the elevation differences (Gedzelman 1980).

3.1.1.1 Temperature and Precipitation

Temperature and precipitation data were recorded from 1961 to 1990 by the National Weather Service (NWS) at a weather station maintained at Kellogg (NWS 2000a). The mean annual temperature for this period was 47°F, with a record high of 111°F and a record low of –36°F (NWS 2000a). For the period 1951 to 1980, an average of 28 days per year reached a maximum temperature of 90°F or greater, while 143 days reached a minimum temperature of 32°F or lower (data from the period 1961 to 1990 for these maximums/minimums have not yet been compiled) (NWS 1985).

The average annual precipitation for the period 1961 to 1990 at the Kellogg weather station was 31 inches. The average monthly precipitation varied from 1.08 inches (July) and 1.43 inches (August) to 4.08 inches (December) and 4.20 inches (January) (NWS 2000a). The annual average precipitation at Wallace was 37 inches (WRCC 2000).

On average, for the period 1961 to 1990, approximately 70 percent of the annual precipitation in the Kellogg area occurred from October to April, mostly as snowfall (NWS 2000a). The mean annual snowfall for the period 1961 to 1990 was 51.9 inches, ranging from 124 inches observed in 1996 to 16 inches observed in 1995 (NWS 2000a). A maximum monthly snowfall of 56 inches was recorded in December 1996.

Snow typically persists at higher elevations from late fall to late spring (MFG 1992). The greater Kellogg area receives warm Pacific moisture as a result of straight zonal flow from the west (MFG 1992). Precipitation from this zonal flow along with a melting snowpack has produced some of the largest floods in the South Fork basin, which have occurred in December through February (MFG 1992).

3.1.1.2 Wind

Winds in the greater Kellogg area are influenced by the mountain/valley topography, creating an upvalley/downvalley (easterly/westerly) flow regime (CDM 1986). Assuming clear weather at night and no large-scale weather patterns over the region, windflow parallel to the axis of the South Fork Coeur d'Alene River valley occurs daily (CDM 1986). This predictable wind pattern results from a process that begins with late-night cooling of the ground layer, causing the formation of a surface-based atmospheric temperature inversion layer. An inversion layer is a condition in which warm air traps cooler air near the surface of the earth, preventing the normal rising of surface air. This inversion layer produces strong, steady down-valley (east to west) winds (CDM 1986). (This same wind pattern is generated at higher elevations on the valley walls and upslope areas [CDM 1986]). Following sunrise, ground heating of the valley floor and mountain slopes causes a reversal of the wind direction to west to east (upvalley) during mid- to late morning (CDM 1986).

3.1.2 CSM Unit 3

CSM Unit 3 is located in the valley portion of the "highland climates" region (Gedzelman 1980). The National Weather Service does not maintain a weather station within CSM Unit 3; therefore, temperature and precipitation data are not available (Brown 2000). Because CSM Unit 3 is located along the main stem of the Coeur d'Alene River valley, wind patterns are similar to the upvalley/downvalley flow regime previously described for CSM Units 1 and 2, although windspeed is generally lower.

3.1.3 CSM Unit 4

Like CSM Units 1, 2, and 3, CSM Unit 4 is located in the "highland climates" region (Gedzelman 1980). Temperature and precipitation data were recorded from 1961 to 1990 by the National Weather Service at a weather station maintained at the Interagency Fire Dispatch office at Hayden Lake (NWS 2000b). The mean annual temperature for this period was 49°F, with a record high of 109°F and a record low of −26°F (NWS 2000b).

The average annual precipitation for the period 1961 to 1990 at the Hayden Lake weather station was 26 inches (NWS 2000b). The average monthly precipitation varied from 0.92 inch (July) and 1.19 inches (September) to 3.6 inches (December) and 3.47 inches (January) (NWS 2000b).

For the period 1961 to 1990, an average of approximately 70 percent of the annual precipitation in the Coeur d'Alene Lake area occurred from October to April, mostly as snowfall (NWS 2000b). Mean annual snowfall data for this period have not yet been compiled.

Wind patterns within the Coeur d'Alene Lake area can be grouped into two categories: (1) flow from the north, out of the Purcell Trench (i.e., a valley immediately north of Coeur d'Alene Lake); and (2) flow from the south-southwest, emanating from the southern Coeur d'Alene Lake valley (Part 1, Figure 1.1-2) (Hammer 2000). Winds from the Purcell Trench bifurcate, with a portion of the flow moving to the southwest along the Spokane River valley and a portion moving south across Coeur d'Alene Lake (Hammer 2000). Wind patterns from the Purcell Trench and the southern Coeur d'Alene Lake valley are generated by processes similar to those previously described for CSM Units 1 and 2.

3.1.4 CSM Unit 5

CSM Unit 5 is located in the climate region referred to as "dry climates," characterized by semiarid to arid (desert) conditions (Gedzelman 1980). The "dry climates" areas are defined as regions where evaporation exceeds precipitation (Gedzelman 1980).

Weather stations at Spokane and Wellpinit (located 7 miles west-northwest of the Long Lake dam) provide representative temperature and precipitation data. At the Spokane station, data was recorded from 1953 to 1983 (NWS 2000c). The mean annual temperature for this period was approximately 50°F, and the average annual precipitation was approximately 18 inches (NWS 2000c). The average annual total snowfall was about 11 inches (NWS 2000c).

Data at the Wellpinit station were collected over a longer period of time than at the Spokane station; temperature and precipitation averages are very similar to those recorded at Spokane. At Wellpinit, the mean annual temperature for the period 1948 through 1999 was about 53°F, and the average annual precipitation was approximately 20 inches (NWS 2000d). The average annual total snowfall was about 47 inches, which is considerably higher than the Spokane snowfall, primarily due to the higher elevation of the Wellpinit station.

In the vicinity of Spokane, the prevailing winds are from the southwest 8 months of the year, and the strongest winds are also from the southwest (NWS 2000c). Prevailing winds flow from the northeast, out of the Spokane River valley, the remaining four months of the year (NWS 2000c). Southwesterly winds apparently originate from Pacific Ocean-based weather systems, whereas northeasterly winds are generated from upvalley/downvalley flow regimes similar to those described for CSM Units 1 and 2 (Hammer 2000).

Wind patterns between Spokane and Franklin D. Roosevelt Lake are complex, very localized, and not as predictable as patterns described for CSM Units 1 through 4 (Hammer 2000).

3.2 GEOLOGY

This section discusses regional aspects of the geomorphic setting, physiographic province, bedrock geology, structural geology, soils, and ore deposits. The Coeur d'Alene Mining district ("the district"), which occupies CSM Units 1 and 2, is the focus of this section because of the abundance of exposed bedrock, the presence of metals in soils associated with ore deposits and igneous rocks, and the presence of important structural features and associated ore deposits. The geomorphic features of all five CSM units are briefly described in the following subsection.

More detailed geomorphic information is presented in Parts 2 through 6 in the discussions of the various watersheds, including drainage energy and flow measurements, depositional/erosional features, width of channels and floodplains, rock/soil types and weathering characteristics, extent of mining activity, and presence and extent of tailings.

3.2.1 Geomorphic Setting

3.2.1.1 CSM Units 1 and 2

The district and immediately surrounding areas are predominantly a continuous mountain mass with no individually distinct ranges (Hobbs et al. 1965). The mass consists of long, sinuous ridges that commonly maintain a fairly uniform altitude, with a gradual decrease in elevation westward from the Bitterroot divide (Figure 1.2-1). Stream valleys are typically steep-walled (or V-shaped) and narrow with general relief on the order of 3,000 feet. The South Fork upstream of Wallace is confined by a V-shaped canyon. Canyon Creek, Ninemile Creek, Moon Creek, and upper Pine Creek are examples of V-shaped canyons (Figure 1.2-2). These reaches have steep gradients, are typically considerably incised, and are channelized by roads, railroads, and mining-related disturbances or naturally by bedrock (Stratus 1999). Bedrock alternates between pinching in and out and creates constrained narrows between wider, shallow reaches with more of a braided character. The North Fork likewise occupies a V-shaped canyon for its entire length until the gradient decreases and its habit changes to a U-shaped canyon upstream from Enaville (where it intersects the South Fork).

The South Fork flows in a westerly direction from the Idaho-Montana border, essentially bisecting the mining district. The river descends from an altitude of 3,600 feet east of Mullan to about 2,100 feet at Kingston, about 25 miles to the west. West of Wallace (Figure 1.2-1), the habit of the river drainage changes from a V-shaped canyon to a U-shaped canyon. Stream and valley gradients decrease and the valley bottom and floodplains widen. The river in this area is best defined as a very active braided stream that is continually eroding its banks and moving large amounts of sediment (Camp Dresser & McKee 1986). Braided streams are characterized by a general instability of bars and channelways and by caving of channel walls (Camp Dresser & McKee 1986). After the formation of an initial channel island, the process of division continues and another bar is formed in one or both of the divided channels (Camp Dresser & McKee 1986).

Mine tailings discharged to the South Fork have been transported downstream by normal fluvial processes to the lateral lakes area (CSM Unit 3), into Coeur d'Alene Lake (CSM Unit 4), and eventually into the Spokane River (CSM Unit 5). SAIC (1993) estimated that of the 110 million tons of tailings generated, an estimated 64.5 million tons of tailings were discharged to the Coeur d'Alene River or its tributaries. Tailings from various sources are mixed, combined with native alluvium, and during seasonal high water, deposited in the floodplains of the Coeur d'Alene River and on the beds and banks of the Coeur d'Alene River, the lateral lakes, Coeur d'Alene Lake, and the Spokane River.

West of the confluence with the North Fork, the river opens into a broad alluvial basin, with the width of the floodplain exceeding 1 mile in places. The river in this area is deeper, meandering, and slower moving.

3.2.1.2 CSM Unit 3

Lateral lakes border the Coeur d'Alene River west of the I-90 bridge at Cataldo. The lateral lakes range in size from 85 acres to more than 600 acres (Ridolfi 1993). Associated with the lateral lakes are thousands of acres of wetlands (Stratus 1999).

3.2.1.3 CSM Unit 4

The Coeur d'Alene River discharges into Coeur d'Alene Lake, a natural submerged riverbed lake. The elevation of the lake is controlled by the Post Falls dam on the Spokane River, near the Idaho state line. The surface area of Coeur d'Alene Lake is approximately 50 square miles, with a mean depth of about 72 feet and a maximum depth of 209 feet (CLCC 1996). The lake has approximately 133 miles of shoreline (Meckel Engineering and Brown and Caldwell 1983) and a drainage area of 3,700 square miles (Woods 1989). The St. Joe River and the Coeur d'Alene River are the two main tributaries of the lake.

3.2.1.4 CSM Unit 5

The Spokane River originates at the mouth of Coeur d'Alene Lake. The river flows in a westerly direction for approximately 110 miles before entering Roosevelt Lake. Dams that control flow along the river include the following:

Post Falls Dam – Owned by Avista Corp. Coeur d'Alene Lake is at a natural level for most of the year; however, May through September the Post Falls Dam is used to keep the lake at higher levels to accommodate recreational use.

Upriver Dam – Owned by the City of Spokane. There is some pool development behind the dam.

Nine Mile Falls Dam – Owned by Avista Corp. There is some pool development behind the dam.

Long Lake Dam – Owned by Avista Corp. Substantial pool development creating Long Lake. Long Lake has a surface area of 8 square miles, a maximum depth of 180 feet, a mean depth of 48 feet and a shoreline length of approximately 46 miles (Ridolfi 1993).

Little Falls Dam – Owned by Avista Corp. There is some pool development behind the dam.

Grand Coulee Dam – There is substantial pool development behind the dam on the Columbia River that creates the Spokane River Arm of Lake Roosevelt.

3.2.2 Physiographic Province

The district is located in the Northern Rocky Mountain physiographic province, which occupies portions of central and northern Idaho and adjacent parts of Montana (Figure 1.2-1, see inset). The district lies in the western part of the province, which consists of a continuous mountain mass with no individually distinct mountain ranges (Hobbs and Frykland 1968). The north-south-trending Bitterroot Mountains demarcate a divide area along the Idaho-Montana state line that separates the Clark Fork drainage on the east side from the Coeur d'Alene River drainage on the west side (Figure 1.2-1).

3.2.3 Bedrock Geology

Rocks of the district are primarily sedimentary formations of the late Precambrian Belt Supergroup (about one billion years old). The sedimentary rocks have been slightly metamorphosed (i.e., altered by heat and pressure) on a regional scale, resulting in the formation of argillite or slate from shale and the formation of quartzite from sandstone. Geologic maps of the district are provided in Figures 3.2-1 and 3.2-2.

The rocks were originally deposited as sediments in a topographic low (called a geosyncline) covering north and central Idaho, western Montana, southeastern British Columbia, and Alberta. The Belt Supergroup is at least 60,000 feet thick, which is consistent with the vast area occupied by the ancient geosyncline.

In the Coeur d'Alene District, the Belt Supergroup has been divided into six formations, the oldest being the Prichard Formation and the youngest being the Striped Peak Formation. The major characteristics and economic importance of these formations as hosts for the ore deposits are indicated in Table 3.2-1. Tables 3.2-2 and 3.2-3 present the 90th percentile distribution of elements in bedrock (by igneous rock type or formation), and Tables 3.2-4 and 3.2-5 present the 90th percentile distribution of elements in soils. Salient features of each of the formations and igneous rock types are described in the following subsections. Geologic cross-sections of Canyon Creek and Ninemile Creek are presented in Part 2, Section 2 of the RI. The description of the formations and rock types includes details regarding the nature and relative abundances of sulfide and carbonate minerals, which influence metal complexing and pH in downgradient sediments and receiving waters.

3.2.3.1 Formations

3.2.3.1.1 Prichard Formation. The Prichard Formation consists of either argillite (more prevalent in the lower part of the formation) or quartzite (more prevalent in the upper part), with the total thickness of the formation estimated to be at least 12,000 feet. The argillite member is typically evenly bedded, medium- to dark-gray, very fine-grained argillite, with pyrite and/or pyrrhotite present as accessory minerals in the lower part of the formation. In outcrops, these sulfides are typically oxidized, leaving the rocks with a characteristic rusty weathered surface (Hobbs et al. 1965). The sulfide content is typically higher in close proximity to ore deposits or large masses of igneous rocks (referred to as igneous stocks).

Lighter colored quartzite, ranging from a hundred to at least a thousand feet thick, is also characteristic of the formation (Hobbs et al. 1965). Wherever the top of the formation is found, it is described as a transition zone from darker colored argillite to lighter colored quartzite.

3.2.3.1.2 Burke Formation. The Burke Formation is predominantly a light greenish-gray impure quartzite that is generally in beds less than 6 inches thick, with lesser amounts of pale red and light yellowish-gray pure to nearly pure quartzite. The total estimated thickness of the Burke is 2,200 to 3,000 feet. The Burke reflects a gradual transition from the underlying predominantly argillitic Prichard Formation to the overlying predominantly quartzitic Revett (Hobbs et al. 1965). Carbonate-rich strata are locally present in the Burke but constitute only about 1 percent of the total volume. Sulfides are not present in appreciable quantities in the Burke (unlike the Prichard) unless in close proximity to ore deposits or igneous stocks.

3.2.3.1.3 Revett Formation. The Revett Formation (commonly referred to as the Revett quartzite) primarily consists of light-colored, thick-bedded fine- to medium-grained, pure quartzite containing interbedded, impure, and nearly pure quartzite in upper and lower parts of a few widely spaced argillite partings. It is the most recognizable and most uniform formation within the district, and the formation thickness is estimated to range from 1,200 to 3,400 feet. Carbonate-bearing quartzites are locally present but do not constitute a significant percentage of the total volume of quartzite in the formation (estimates of the volume of carbonate-bearing quartzite are not available). Sulfides are not reported for the Revett (unlike the Prichard), unless in close proximity to ore deposits or igneous stocks (discussed later). A conspicuous oxidation product consisting of an iron oxide carbonate mineral is present in many of the pure quartzite beds; it is believed that this carbonate mineral is either an iron-rich dolomite or an iron-rich calcite. (Dolomite is a calcium-magnesium carbonate mineral; calcite is a calcium carbonate mineral.) Where present, this carbonate mineral typically accounts for only 1 percent or less of the rock (Hobbs et al. 1965).

3.2.3.1.4 St. Regis Formation. The St. Regis Formation is underlain by the Revett quartzite, and both formations grade into each other through a transition zone several hundred feet thick. This transition zone is characterized by increasingly less pure quartzite grading into impure quartzite and interbedded argillite. The St. Regis is estimated to range from 1,400 to 2,000 feet thick, and is divided into a lower part and upper part. The lower part reflects a continuation of the transition zone between the Revett and St. Regis, characterized by the gradational change into increasingly impure quartzite and argillite. A red-purple to grayish-red color is a diagnostic characteristic of the lower St. Regis (Hobbs et al. 1965).

The upper St. Regis consists of thin-bedded impure quartzite and argillite. Green-colored rocks dominate in the upper part and the grayish-red color is virtually absent. Throughout the district, a zone of thinly bedded greenish argillite occurs at the top of the St. Regis below the overlying Wallace Formation (Hobbs et al. 1965).

Carbonate-bearing rocks are mostly restricted to the quartzitic beds; carbonates are more prevalent toward the top of the formation but make up only a small percentage (exact percentage not provided) of the formation (Hobbs et al. 1965). Sulfides are not reported in the St. Regis, unless in close proximity to ore deposits or igneous stocks.

3.2.3.1.5 Wallace Formation. Like the St. Regis, the Wallace Formation is divided into a lower and upper part. There are by far more carbonate-bearing rocks in the Wallace than in the other formations of the Belt Supergroup. The lower part of the Wallace is composed of alternating beds of carbonate-bearing argillite and quartzite, with interbedded zones of impure dolomite and dolomitic quartzite. The upper part consists of thinly laminated argillite separated by a thin central zone of dominantly dolomitic rock. A complete uninterrupted section of the Wallace is not exposed; the total thickness of the formation is estimated to be between 4,500 and 6,500 feet (Hobbs et al. 1965).

Both quartzite and argillite layers are frequently carbonate bearing. The carbonate mineral calcite is present, but probably the most abundant carbonate mineral is an iron-rich dolomite, which stands out because of the rusty red or brown stain on weathered surfaces (particularly quartzite). Sulfides are not reported in the Wallace Formation, unless in close proximity to ore deposits or igneous stocks (Hobbs et al. 1965).

3.2.3.1.6 Striped Peak Formation. The Striped Peak Formation is reddish to greenish-gray, impure to nearly pure quartzite and lesser argillite. The transition from the darker colored argillitic rocks of the underlying upper Wallace Formation to the lighter colored Striped Peak rocks is relatively thin, and the contact is placed at the beginning of the purer quartzite beds assigned to the Striped Peak Formation. A complete section of the Striped Peak Formation is not exposed. A 1,500-foot-thick outcrop of the formation is exposed near Striped Peak itself (Figure 3.2-3); however, the total thickness of the formation is estimated to be at least 2,000 feet (Hobbs et al. 1965).

The predominantly quartzitic rocks of the formation display a rusty, pitted surface from the oxidation of iron-rich carbonate (probably dolomite). Sulfides are not reported in the Striped Peak Formation, unless in close proximity to ore deposits or igneous stocks (Hobbs et al. 1965).

Intruding the Precambrian Belt Supergroup sedimentary rocks are younger, Cretaceous-aged igneous stocks and igneous dikes. An igneous dike is a tabular body of igneous rock that cuts across the structure of adjacent rocks. A summary of the four general groups of igneous rocks follows.

3.2.3.2 Igneous Rocks

Igneous rocks have been divided into four general groups: (1) several small monzonite stocks, (2) diabase dikes, (3) lamprophyre dikes, and (4) a group of compositionally diverse intrusive bodies that are collectively referred to as "other dikes" (Hobbs et al. 1965). Figures 3.2-1 and 3.2-2 show the distribution of the known igneous rocks in the project area.

3.2.3.2.1 Monzonite Stocks. The monzonite stocks are referred to as the Gem stocks and the Dago Peak stocks. The largest masses of igneous rock are the two Gem stocks, generally located between Ninemile and Canyon Creeks (Figure 3.2-2). The southern mass crops out in an area of 2.8 square miles, and the northern mass crops out in an area of 1.0 square mile. Occupying areas less than 1.0 square mile are the Dago Peak stocks, located approximately 3 miles west of the Gem stocks.

Compositionally, the stocks are primarily monzonite to quartz monzonite, with lesser portions of the igneous masses classified as diorite or syenite. The main rock-forming minerals in the monzonites are approximately equal amounts of potassium feldspar and plagioclase (calcium) feldspar, with hornblende and pyroxene (dark-colored, iron-magnesian minerals), and quartz (less than 5 percent quartz for monzonite, greater than 5 percent for quartz monzonite). Diorite has essentially the same minerals as monzonite but a higher percentage of plagioclase feldspar than potassium feldspar. Syenite has a higher percentage of potassium feldspar than plagioclase feldspar, a lower percentage of hornblende and pyroxene compared to monzonite, and roughly equal percentages of quartz.

In addition to the Gem and Dago Peak stocks, geophysical data indicate that a buried stock (referred to as the Atlas pluton), possibly compositionally similar to the Gem stocks, exists at an approximate depth of 3,500 feet near the Carbonate Hill (Atlas) Mine south of Mullan (Figure 3.2-3) (Gott and Cathrall 1980).

3.2.3.2.2 Diabase Dikes. Diabase dikes are widespread throughout the district but are most numerous south of the Osburn Fault (Hobbs et al. 1965). Most of the dikes trend between west and northwest and can be traced for distances up to 1 to 3 miles and possibly more, owing to discontinuous outcrops of the dikes. In outcrop the dikes are tens of feet wide or less and typically fill preexisting fractures and faults. Compositionally, the dikes are primarily composed of plagioclase feldspar and pyroxene, with lesser amounts of potassium feldspar, sodium feldspar, quartz, and the following fine-grained accessory minerals: apatite (a calcium phosphate mineral), ilmenite (an iron titanium oxide), and magnetite (an iron oxide) (Hobbs et al. 1965). Sulfides and carbonates are rare, fine-grained accessory minerals.

Based on cross-cutting relationships, the dikes are older than some of the sulfide mineralization but younger than the main period of ore deposition (although age relationships with the ore deposits are not clear cut). The dikes are also younger than the monzonite stocks and younger than the fractures and faults they occupy (Hobbs et al. 1965).

3.2.3.2.3 Lamprophyre Dikes. Lamprophyre dikes are prevalent in mine workings and roadcuts throughout the district but are most numerous north of the Osburn Fault (Hobbs et al. 1965). Most of the dikes trend north-northwest or less commonly northwest to northeast, which is different from the west-northwest trend of the diabase dikes. In outcrop the dikes are usually a few feet to a few tens of feet wide, and none has been traced continuously for more than a fraction of a mile.

The lamprophyre dikes are primarily composed of biotite and hornblende (both iron-magnesian minerals), with lesser amounts of plagioclase feldspar, potassium feldspar, sodium feldspar, pyroxene, quartz, and the accessory minerals apatite and magnetite. Sulfides and carbonates are rare, fine-grained accessory minerals. Hobbs et al. (1965) and others have mapped the lamprophyre dikes as younger than the diabase dikes, monzonite, and ore deposits.

3.2.3.2.4 Other Dikes. Throughout the district are dikes that vary in composition from lamprophyric (although sufficiently distinct to classify them separately from the lamprophyre dike category), through diorite and monzonite, to aplite. The diorite and monzonite dikes are likely offshoots from the diorite and monzonite stocks. Like the stocks, the dikes are older than the ore deposits, as evidenced by veinlets of sphalerite (zinc ore) that penetrate the dikes. Aplite dikes are a fine-grained, light-colored rock that contain more quartz than monzonite, and virtually no dark-colored iron-magnesian minerals or accessories. Based on cross-cutting relationships, aplite dikes are younger than the stocks (Hobbs et al. 1965).

3.2.4 Structural Geology

The district is complexly faulted and centered near the intersection of two regional structural elements. A broad, north-trending highland (or anticlinal arch) extends from the north end of the district into British Columbia; this highland is known as the Trout Creek anticline. The other regional element is the Lewis and Clark line, a formidable zone of complex folding, faulting, and shearing that trends in an east-southeast direction for approximately 500 miles from Spokane, Washington, to central Montana (Hobbs et al. 1965).

Coincident with the Lewis and Clark line is the principal structural feature of the district, the 100-mile-long Osburn Fault (Figures 3.2-1 and 3.2-2). The Osburn is a strike-slip fault with approximately 16 miles of right-lateral (east-west) displacement or movement. The ore deposits along this fault in the Kellogg area (south of the fault) and the Mullan-Burke area (north of the fault) originally formed at one location and were subsequently separated and moved approximately 16 miles along the fault to their present location.

The probable original location of the Dago Peak stocks coincident with the Gem stocks, followed by subsequent movement and separation after faulting, is another aspect of the structural evolution of the district. Note the location of the Dago Peak stocks to the west of the Gem stocks in Figure 3.2-2; normal faulting has transported the Dago Peak stocks to their present location.

3.2.4.1 South of Osburn Fault

In addition to the Osburn Fault, a variety of faults dominate the structure of the district. The Placer Creek fault is 3 to 4 miles south of the Osburn Fault and runs parallel to it (Figures 3.2-1 and 3.2-2). Within the zone between the two faults are many steeply dipping, northwest-trending faults that form connecting links between the Osburn and Placer Creek structures. The sedimentary Belt Supergroup south of the Osburn displays tightly compressed folding with fold axes trending in a westerly direction (Hobbs and Frykland 1968).

3.2.4.2 North of Osburn Fault

Two sets of faults are north of the Osburn. One set runs west-northwest, roughly parallel to the Osburn, and the other set trends north (e.g., Dobson Pass, Carpenter Gulch, and Blackcloud faults) (Hobbs and Frykland 1968). In contrast to the Belt Supergroup strata south of the Osburn, folding north of the Osburn is less tightly compressed and fold axes trend in a northerly direction (Hobbs and Frykland 1968).

3.2.5 Soils

Soils in the district can be grouped into two broad categories: hillside soils and valley soils (MFG 1992; Camp Dresser & McKee 1986). Unless otherwise indicated, this section describes soils that have not been disturbed by mining activities.

3.2.5.1 Steep Hillside Soils

Hillside soils with slopes greater than 35 to 45 percent are colluvial in nature, derived primarily from mechanical and chemical weathering of sedimentary rocks from the Belt Supergroup. Surface layer thicknesses typically vary from 4 to 16 inches of gravelly silt loam. Loam is defined as a permeable soil with relatively equal proportions of clay, silt, and sand particles, with some organic matter. Underlying this loam layer is cobbly loam to weathered bedrock at depths of 40 to 60 inches below the ground surface (bgs). These two loam-rich soil horizons are moderately acidic (pH values typically 5.0 to 7.0) and moderately eroded. Their water-holding capacity is 3 to 6 inches (MFG 1992; Camp Dresser & McKee 1986).

3.2.5.2 Moderate Hillside Soils

Hillside soils with slopes of 5 to 35 percent can be grouped as silty/silty clay loam (generally less than 12 inches thick) underlain by cobbly/gravelly loam to the top of weathered bedrock at 40 or more inches bgs. These soils are generally strongly acidic, relatively impermeable, and heavily eroded. Their water-holding capacity is 3 to 9 inches (MFG 1992; Camp Dresser & McKee 1986).

3.2.5.3 Valley Soils/Alluvium

Soils on the valley floors are an unconsolidated mixture of sand, silt, clay, gravels, cobbles, and boulders resulting from the erosion of the Belt Supergroup rocks, reworked glacial deposits, and recent volcanic ash. The various types of valley soils have been grouped together as Quaternary alluvium (Qal, see Figures 3.2-1 and 3.2-2). Alluvium thicknesses vary from 30 feet at Wallace to more than 400 feet at Rose Lake (Camp Dresser & McKee 1986). Soils are stratified, commonly exhibiting gravel-rich layers on the order of 15 to 20 feet thick, alternating with silt-rich layers (Camp Dresser & McKee 1986). Included with the Quaternary alluvium are tailings and related materials produced by mining activities. Tailings and tailings-bearing sediment of the mining era overlie Quaternary alluvium of the pre-mining era. Tailings are discussed further in Section 4, "Nature and Extent of Contamination," for each watershed.

Studies conducted by Gott and Cathrall (1980) identified geochemical dispersion patterns in soil and bedrock around igneous bodies and ore deposits.

Tables 3.2-4 and 3.2-5 present the 90th percentile distribution of antimony, silver, lead, manganese, and copper in soils within the various rock types and formations from which the soil formed.

3.2.6 Ore Deposits

3.2.6.1 Origin of Deposits

Over the years, differing interpretations of the age and formation of the ore deposits in the district have been proposed. The age of vein emplacement has been variously placed from periods as old as Precambrian to those as young as Cetaceous. Similarly, varying hypotheses on the origins of the metals in the veins have attributed them to intrusive magmas, a deep subcrustal source, and the Belt sediments (White 1998). The most recent evidence, as summarized by White (1998), places the age of the veins in the Late Cretaceous period, and proposes that the metals originated from metamorphism of the sediments and are associated with intrusions from the Idaho batholith.

3.2.6.2 Production Figures

The Coeur d'Alene district is one of the largest lead-, zinc-, and silver-producing areas in the world, with production of approximately 1.2 billion ounces of silver, 8 million tons of lead, and 3.2 million tons of zinc (Long 1998). The ore deposits are clustered in west-northwest to northwest-trending areas called mineral belts, which are structurally controlled, linear zones defined by veins that occupy faults and fractures. Most of the silver-dominant ores comes from the Silver Belt, an eastern subbelt which is part of the Page-Galena Belt (Figure 3.2-3).

3.2.6.3 Veins

The ore deposits occur in steeply dipping veins consisting of variable amounts of ore minerals and non-ore minerals. Many of the ore deposits in the district contain disseminated gelene sphalerite, pyrite, and arsenopyrite (White 1998). Most of the veins range in width from a fraction of an inch to 10 feet, and occasionally up to 50 feet wide. In general, the type, grade, and location of the deposits do not seem to be affected by depth (Hobbs and Fryklund 1968). Individual ore shoots (i.e., ore-bearing zones within the veins) range in length from a few tens of feet to over 4,000 feet. Their dip length is usually several times the strike length, and generally they rake steeply in the plan of the vein (Hobbs and Fryklund 1968). Ore minerals are the components of an ore that are economically feasible to extract. The ore minerals in these veins are sphalerite (zinc sulfide [ZnS]), galena (lead sulfide [PbS]), and argentiferous tetrahedrite (an arsenic-antimony sulfide with varying proportions of copper, iron, zinc, and silver).

Table 3.2-6 presents representative chemical analyses of tetrahedrite from two mines within the district and underscores the relatively high silver contents of the ore minerals in this district. In addition to galena, tetrahedrite is the most important silver ore mineral. Galena is the most abundant ore mineral in the district, followed by sphalerite and then tetrahedrite. The non-ore minerals are primarily quartz (SiO_2) and siderite, an iron carbonate ($FeCO_3$). With regard to the sulfides, zinc concentrations are typically at least one to two orders of magnitude higher than the geochemically similar cadmium.

3.2.6.4 Deposit Types

There are three general types of vein deposits in the district; one in the middle Prichard quartzites (zinc-lead orebodies on Pine Creek), another in the Prichard-Burke transition zone (Ninemile Creek and Canyon Creek lead-zinc deposits), and the third in the Revett-St. Regis transition zone (Bunker Hill Mine, Star-Morning Mine, Lucky Friday Mine, and the mines in the Silver Belt; see Figure 3.2-3) Bennett and Venkatakrishan, 1982). The orebodies in the Revett-St. Regis transition zone are found where relatively pure quartzite grades into impure quartzite, followed by argillite. The relatively pure quartzite is largely assigned to the Revett quartzite, and the overlying impure quartzite and argillite are assigned to the St. Regis Formation (White 1998). (For completeness, note that stratabound copper-silver deposits, unrelated to the vein deposits, are present in the northeastern part of the district, e.g., Snowstorm and National Mines [Figure 3.2-3].)

Throughout the district, most of the ore is associated with quartzite layers in the Belt Supergroup rocks. The Revett quartzite accounts for approximately 75 percent of the historical ore production; 19 percent is from the quartzite at the Burke-Prichard transition zone; and all current production is from the Revett-St. Regis boundary (White 1998).

3.2.6.5 Depth of Deposits

Deposits in the northern and western part of the district are, in general, relatively shallow, and deposits east of the Bunker Hill Mine in the Silver Belt are on the order of 1,000 feet deep (Gott and Cathrall 1980). At locations where the veins do outcrop (or are exposed) on the surface, they are typically deeply weathered and their surface expression represents only a small fraction of their extent at depth (Stratus 1999). Some vein systems apex 1,000 feet or more below the surface, and give little or no hint on the surface of their existence (Hobbs and Fryklune 1968).

3.2.6.6 Carbonate Zonation Around Veins

There is abundant evidence that zones (or halos) of carbonate, primarily disseminated siderite (i.e., iron carbonate), are present around many of the veins of the district. The zones of siderite can extend from tens to hundreds of meters wide surrounding the veins (White 1998). Peripheral to the siderite zone may be a zone of siderite plus ankerite $(Ca[Fe,Mg]CO_3)_2$ that is up to tens of meters wide (White 1998). This zone in turn may be surrounded by a broad zone of ankerite and calcite ($CaCO_3$) that is up to hundreds of meters wide (White 1998). The carbonate zones tend to extend farther out (away from veins) in quartzitic strata than they do in the finer-grained (e.g., argillite) strata (White 1998). Additionally, zones extend farther into strata that dip into the vein (White 1998).

Weathering of these carbonate zones may produce more alkaline stream waters (and probably more alkaline groundwater), with relatively high amounts of iron and lesser amounts of calcium and magnesium. However, alkalinity from carbonate zoning may be buffered by acidic waters generated from sulfide-rich zones around many veins in the district.

3.2.6.7 Sulfide Zonation Around Veins

Zones of disseminated galena, sphalerite, arsenopyrite, and pyrite are also found around many of the orebodies in the district (White 1998). Like the carbonate zones, sulfide zones extend farther along permeable strata than along finer-grained strata (White 1998). For example, disseminated galena at the Lucky Friday Mine extends for tens to hundreds of meters outside of veins where strata dip into the vein, but only for 1 to 3 meters where strata dip away from the vein (White 1998).

The weathering of disseminated sulfide zonation peripheral to the veins could produce waters that contain elevated concentrations of metals (Stratus 1999).

3.2.6.8 Vertical Zonation Within Veins

Vertical zonation is absent at most mines in the district (Hobbs and Frykland 1968). However, exceptions to this lack of vertical zonation are observed in veins in the Silver Belt mines. White (1998) reported that pyrite and chalcopyrite (the principal ore mineral of copper) increase with depth. Galena is more abundant at higher levels, and tetrahedrite increases with depth (White 1998). In Silver Belt veins with deeper orebodies, metal ratios can vary widely (White 1998).

The Morning-Star Mine (Figure 3.2-3) is one of the few mines outside the Silver Belt that exhibit vertical zonation. The Morning-Star is one of the deepest (8,500 feet deep) and largest producers in the district, and pyrite is more abundant at depth (White 1998). The Hercules Mine is another mine outside the Silver Belt with evidence of vertical zonation (Figure 3.2-3); here, pyrite decreases and pyrrhotite increases with depth (Hobbs and Fryklund 1968). The only other mine outside the Silver Belt with evidence of vertical zonation is the Page, where galena concentrations decrease with depth, and sphalerite increases with depth.

3.3 GEOCHEMISTRY

The chemistry of most surface waters and groundwaters is the result of interactions between rain or snowmelt and rocks near the earth's surface. Mining activity in the basin has exacerbated the natural weathering of various metal-bearing minerals by exposing them to additional water and oxygen thereby resulting in additional releases of metals to surface water and groundwater. Elevated metals concentrations are found throughout the Coeur d'Alene River basin. This section presents the processes that control the chemistry (composition) of surface waters and groundwaters related to bedrock, soils, sediments, ore deposits, and mining wastes within the Coeur d'Alene River basin.

Building on the CSM introduced in Section 2, and the regional geology presented in Section 3.2, this section includes general descriptions of the sources, release mechanisms, movement, and attenuation of metals within the system included in a Conceptual Model. Detailed descriptions of the primary geochemical reactions that control mobilization and attenuation are presented in Appendix G. Primary geochemical reactions introduced in this section and described in detail in Appendix G includes dissolution/precipitation, adsorption/desorption, and oxidation/reduction reactions. These reactions are interrelated and control the movement of metals from source rock to and between surface water, groundwater, and sediment throughout the basin. A principal component related to and resulting from these reactions is pH. Acid generating minerals in the basin (e.g., pyrite) result in acid pH values and the mobilization of metals into solution, whereas significant amounts of acid neutralizing minerals (e.g., calcite) increase the pH and can result in precipitation of metals from solution.

3.3.1 Conceptual Model

Sources, release mechanisms, movement, and attenuation of metals in surface water, groundwater, and sediment of the Coeur d'Alene River basin are discussed in this section. Given the complexity and size of the basin, different processes may be important at different locations within the basin. For this reason, processes for the basin from the headwaters of the South Fork to Coeur d'Alene Lake and from Coeur d'Alene Lake through the Spokane River are discussed first, followed by processes for Coeur d'Alene Lake.

3.3.1.1 Main Stem, Lateral Lakes, South Fork, Spokane River and Tributaries

Sources, release mechanisms, movement, and attenuation of metals in surface waters and groundwaters of the Main Stem, lateral lakes, South Fork, and tributaries are illustrated in Figure 3.3-1. The Spokane River is shown in conjunction with Coeur d'Alene Lake in Figure 3.3-2.

The primary sources of metals observed in surface water and groundwater are ores, disseminated tailings, tailings piles, and waste piles located within the basin. Metals are released primarily through oxidation of sulfides in the ores, tailings piles, and waste piles. In the oxidation process, metals (e.g., lead, zinc, and cadmium) are transformed from a highly immobile to a relatively mobile state. This transformation takes place as sulfides come into contact with water and the atmosphere, are oxidized, and are replaced by minerals and solid phases (e.g., oxides and sulfates) with greater potential mobility. The oxidation process itself may release hydrogen ions and lower the pH. Metals tend to be more soluble (and mobile) at lower pH values. Even at neutral pH values, however, high metal concentrations may be found.

After release from ores, tailings, and waste materials, metals migrate in dissolved (ionic) and particulate forms (as adsorbed metals and as primary and secondary minerals) in surface waters of the Main Stem, South Fork, North Fork, Spokane River, and tributaries. At least part of the particulate metal load occurs as metals adsorbed onto precipitated iron (iron oxyhydroxides). Another portion of the suspended particulate load arises from tailings generated through the milling processes. Additionally, metals migrate as bedload material. Whereas finer particles are suspended in solution, metals migrating as part of the bedload are often associated with larger particle sizes (e.g., sand-sized and larger). Bedload particles can consist of mixtures of natural sediments, erosive soils, tailings, and fine waste rock and can skip or roll along the streambed. The environmental occurrence and chemistry of the ten metals of potential concern studied in this RI are presented in Appendix G.

Surface waters discharge to groundwater, lakes and other surface water bodies. Because of the soil's ability to filter particulate material, it is anticipated that metal migration in groundwater will occur primarily in the dissolved form. Accordingly, metals will be discharged from groundwater to surface water predominantly in the dissolved form.

Particulate metal loading is especially pronounced during the highest flow-events. High-flow periods usually occur in the spring as a result of precipitation and snowmelt but can occur in midwinter for the same reasons. Upon entering the South Fork, dissolved and particulate metals are transported downstream. In general, where rivers widen into floodplains there is a tendency for surface water to discharge to groundwater. Conversely, in areas where the river channel narrows, groundwater tends to discharge metals to the river system, again, principally in the dissolved phase.

As suspended or bedload particles are transported by the river system, there is a possibility that, depending on chemical conditions, metals will desorb from the sediments and enter the river in the dissolved (ionic) phase. Furthermore, metals may enter the river from riverbank porewater. During high flow events, riverbanks and adjacent floodplain areas store water. The stored pore water can increase in concentration as metals desorb from sediments or as precipitated solid phases and minerals dissolve. As the waters subside, these dissolved metals can reenter the river surface water system from bank storage and can subsequently impact the quality of downstream waters.

Physical erosion of riverbanks and channels also causes particulate forms of metals to reenter the river and be transported. There is an increased propensity for erosion during high-flow events and following high-flow events when river banks are saturated and the river stage decreases. Additionally, efflorescent metal salts can be formed by evaporation from mine waste materials carried previously by flood events to overbank locations. These water soluble metal salts can reenter the river during rainstorm events or subsequent high-flow events. Efflorescent salts are expected to be composed of moderately soluble salts such as metal sulfates. The particulate (suspended and bedload) and dissolved load of the Main Stem discharges directly into Coeur d'Alene Lake.

3.3.1.2 Coeur d'Alene Lake

Sources, release mechanisms, movement, and attenuation of metals in surface waters and sediments of Coeur d'Alene Lake and the Spokane River near the mouth are presented in Figure 3.3-2.

Unlike the Coeur d'Alene River, few mining activities have occurred in the areas surrounding Coeur d'Alene Lake. The primary source of metals to the lake is the Coeur d'Alene River. As dissolved and particulate metals enter Coeur d'Alene Lake from the Main Stem, many particulates settle to the bottom as the velocity slows and the gradient becomes less steep. Bedload, especially, will be deposited in the area of the delta. Suspended particulates will move farther into the lake than bedload materials before settling out of the water column. The majority of metals still associated with particulates such as iron and manganese oxides, organic matter and silt/clays, will eventually move through the water column and rest on the lake bottom. The rest of the metal particulates (and colloids), may move through the lake and into the Spokane River. As particulates move in Coeur d'Alene Lake, some of the metal load may desorb from the particulates and enter the aqueous phase in dissolved form. The environmental occurrence and chemistry of the ten metals of potential concern studied in this RI are presented in Appendix G.

Depending on their comparative water temperatures, water entering the lake from the Main Stem may flow across the surface of the lake (overflow) or sink and flow along the lake bottom (underflow). Additionally, water entering the lake may flow through the middle of the lake (interflow), however interflow is less prevalent than underflow or overflow. Typically, from October to December, underflow will take place, while from March to September, overflow occurs (Woods 2000). Overflow occurs because the shallow river water warms more rapidly and becomes less dense than the relatively deep (and large volume) water in the lake. During the period (October to December) when underflow occurs, the opposite phenomenon takes place.

That is, the river water cools more rapidly and becomes denser than the lake water and tends to sink and flow across the lake bottom.

A portion of the dissolved and particulate metal load moves through Coeur d'Alene Lake and enters the Spokane River. Mass balance calculations (Woods 2000) indicate that more metals enter Coeur d'Alene Lake on an annual basis from the Main Stem than exit the lake to the Spokane River. Therefore, a portion of the metal mass entering the lake remains there. Dissolved metals can be transported to the lake bottom in particulate form as they adsorb onto metal oxides, organic matter, phytoplankton, and silts and clays as these particulates move through the water column.

Coeur d'Alene Lake is oligotrophic with dissolved oxygen found throughout the water column except for particular areas of the lake during certain times of the year. This oxygen will diffuse into the upper few centimeters of the lake bottom causing an oxidizing zone to exist in the upper portion of the bottom sediments (Figure 3.3-2). Sediments found deeper in the sediment profile because of deposition subsequent to their placement, become more reducing and metal oxides may dissolve. Dissolution of metal oxides releases adsorbed metals such as lead, zinc, and cadmium. A portion of these metals may diffuse deeper into the sediment profile while another portion diffuses towards the upper oxidizing zone. Metals diffusing deeper into the sediments will eventually encounter conditions sufficiently reducing to reduce sulfates to sulfides and the migrating metals may precipitate as metal sulfides. Metals diffusing towards the upper layers of the sediments will eventually encounter oxidizing conditions where they may readsorb onto metal oxides, organic matter, etc., or continue to migrate upward into the lake's water column. Metals that reach the deeper sediments and precipitate as metal sulfides should remain indefinitely in this state unless the sediments are disturbed. Metals that diffuse from bottom sediments and reenter the lake in the dissolved phase may be transported to the Spokane River or readsorb onto particulates and begin the cycle again as lake bottom material. Other forces, besides diffusion, that can cause a benthic flux to the lake are bioturbation and advection. However, the benthic community currently is not considered large enough for bioturbation to be a significant contributor to benthic flux. Furthermore, advection is assumed to be a minor contributor to benthic fluxes compared to diffusion (personal communication from USGS, April 27, 2000, Woods, 2000).

Balistrieri (1998) evaluated water column and sediment pore-water data collected by the USGS in 1992 and reported by Woods and Beckwith (1997). Balistrieri's calculations indicated that benthic fluxes of metals from the sediment pore waters to the lake were occurring. Computations indicated that Zn, Cu, Mn, and possibly lead are migrating from sediment pore waters to the overlying lake waters. On the basis of benthic flux measurements made in August of 1999 by the

USGS (Kuwabara et al. 2000; Woods 2000), benthic fluxes of dissolved cadmium, zinc, inorganic nitrogen, and orthophosphorous were of similar magnitude to those delivered to the lake by the Coeur d'Alene and St. Joe Rivers.

3.4 HYDROGEOLOGY

The Coeur d'Alene River basin is part of a regional groundwater flow regime described as the Northern Rocky Mountain intermontane basin aquifer system (Whiteman et al. 1994). Within the Coeur d'Alene River basin (CSM Units 1, 2, and 3), two primary aquifer systems are recognized, including (1) a regional bedrock aquifer developed within fractured Belt Supergroup metasedimentary units and (2) alluvial aquifers developed within the valley-fill sediments. This regional groundwater flow system maintains a high degree of hydraulic interaction with the Coeur d'Alene River (North Fork, South Fork, and main stem).

Both the river and aquifer system discharge to Coeur d'Alene Lake, a large freshwater lake over 20 miles long, having a depth of up to 200 feet. In addition to the Coeur d'Alene River, Coeur d'Alene Lake also is the surface water receiving body for other regional drainage systems, including the St. Joe and St. Maries Rivers. The approximate 15-mile reach of Coeur d'Alene Lake (CSM Unit 4), from the mouth of the Coeur d'Alene River to the Lake's northern margins near the city of Coeur d'Alene, provides a hydraulic continuum between the groundwater flow system within the Coeur d'Alene River Valley (CSM Units 1, 2, and 3) and the Spokane Valley/Rathdrum Prairie Aquifer system (CSM Unit 5).

The following discussions under Section 3.4 provide a general overview of basin-wide hydrogeologic conditions, leading to the development of a conceptual hydrogeologic framework that describes regional groundwater occurrence, groundwater flow, and anticipated groundwater/surface water interactions. There are distinct geographical and hydrogeologic differences between the mountainous CSM Units 1, 2, and 3 and the Coeur d'Alene Lake and Spokane River CSM Units (CSM Units 4 and 5, respectively). Because of these differences, the areas are discussed separately in this section. The hydrogeology of CSM Units 1, 2, and 3 is discussed first in Section 3.4.1, followed by a separate discussion of CSM Units 4 and 5 in Section 3.4.2.

3.4.1 Hydrogeology—CSM Units 1, 2, and 3

3.4.1.1 Hydrogeologic Overview

Two predominant hydrogeologic flow regimes are operative within CSM Units 1, 2 and 3: groundwater within fractured bedrock consisting primarily of Belt Supergroup Series quartzites and argillites, and groundwater within fine to coarse alluvial deposits within the Coeur d'Alene River Valley and its major tributary valleys. Within the bedrock aquifers, groundwater movement is strongly controlled by local and regional structural features such as faults. The hydraulic conductivity of the unfractured native bedrock is quite low, and thus fracture flow is the most important component of groundwater flow. As a result, the orientation of spatially continuous, permeable fractures or fracture zones dictates the direction of regional flow (Demuth 1991). Local to subregional bedrock aquifer flow systems develop within individual tributary basins. Recharge to the bedrock system occurs predominantly via snowmelt and direct precipitation infiltration in the higher elevations. Groundwater discharge occurs within the valley-bottom areas, either as discrete seeps, or as subsurface recharge to the valley floodplain alluvial deposits. In areas where underground mining has occurred, the mined out area can serve as a manmade zone of groundwater discharge, that can cause localized desaturation within a cone of depression around the mine workings.

A network of shallow unconfined aquifers, long and narrow in dimension, develops within the coarse and permeable alluvial sediments that were deposited within the upper valley-floodplain areas (CSM Units 1 and 2). These aquifer systems generally show a relatively steep hydraulic gradient, similar to the gradient of the local topography, and are sustained by stream loss or groundwater discharge from the bedrock aquifer system. Groundwater flow in these shallow, alluvial aquifer systems tends to parallel the course of the surface water flow. A high degree of hydraulic interaction often exists between shallow groundwater and surface water. Also, groundwater within the unconfined aquifers can hydraulically interact with groundwater within tailing impoundments found in several locations within the CSM Units 1 and 2.

Within the lower reaches of the South Fork (CSM Unit 2), three predominant hydrostratigraphic units are differentiated within the alluvial sediment sequence:

- An unconfined, alluvial, sand and gravel aquifer (upper zone)
- A low-permeability lacustrine silt/clay aquitard (confining zone)
- A confined, sand and gravel aquifer (lower zone)

Both upward and downward vertical hydraulic gradients exist across the confining unit, and both gaining and losing reaches of the river are observed.

Lower portions of the Coeur d'Alene River valley, inclusive of CSM Unit 3, contain alluvial sediments that are finer grained and less permeable than their upstream counterparts. In this portion of the valley, many lakes and wetlands are present within the floodplain. The hydraulic interaction between lakes, wetland, river, and shallow groundwater is complex and dynamic. Rates of groundwater flow in portions of the basin can be quite low due to the low permeability of the alluvial sediments and the shallow hydraulic gradients.

3.4.1.2 Groundwater Usage and Monitoring Networks

3.4.1.2.1 Groundwater Usage. Groundwater usage within the Coeur d'Alene River valley is most concentrated within the larger communities that are located along the valley flanks and valley bottom areas. Several investigators (MFG 1996; Piske 1990; Norbeck 1974) included well inventories as part of their investigations of the groundwater resource. Well yields of up to several hundred gpm have been reported for larger alluvial production wells within the South Fork Coeur d'Alene River valley. Few deep wells were identified by the well inventories compiled for the lower main stem of the Coeur d'Alene River. Wells installed in the bedrock aquifer system generally have lower average yields due to the lower intrinsic permeability of the metasedimentary units.

3.4.1.2.2 Monitoring Well Networks. Groundwater monitoring wells and piezometers have been installed at several study areas within the Coeur d'Alene River valley to facilitate measurement of groundwater levels and allow collection of groundwater quality samples. Ridolfi (1995) provided a summary of groundwater quality studies that were performed by agencies, universities, and the private sector, several of which included installation of a groundwater monitoring wells. The current condition and accessibility of these monitoring wells are not known.

3.4.1.3 Regional Groundwater Systems

Regional groundwater flow systems within the Coeur d'Alene River valley can be divided broadly into two categories: (1) groundwater flow through naturally fractured metasedimentary bedrock, and (2) groundwater flow through unconsolidated alluvial deposits within the river floodplain and major tributaries. Other localized occurrences of groundwater, such as perched zones within the native colluvium and saturated mine tailings within above-grade impoundments, also are present within selected areas of the watershed. Although the tailings impoundment areas cover only a small portion of the basin and have a limited hydraulic impact at the regional level, they do have a significant impact on both local and regional groundwater and surface water quality and are therefore important to the overall understanding of chemical impacts that occur in the basin.

Basalt of the Columbia River Group also is present within the lower reaches of CSM Unit 3, extending approximately 8 miles upstream from the mouth. Well logs for the City of Harrison show that basalt occurs to a depth of at least 275 feet below lake level (Piske 1990). The basalt flows are interspersed with outcrops of the Belt Series Supergroup. The hydraulic characteristics and groundwater flow conditions within the layered extrusive rocks are expected to differ from the Belt Series Supergroup rocks. However, due to the limited areal extent of the basalt and the paucity of basin-specific hydrogeologic data, no separate discussion of groundwater conditions within the Columbia River basalts is presented in this report.

3.4.1.3.1 Perched Hydrologic Regimes and Mine Wastes. Perched groundwater conditions are expected to occur locally in upland portions of the basin where sufficiently thick soil and colluvial material overlie the native low-permeability bedrock. Perched groundwater could be expected to occur most frequently at or near the soil/bedrock interface and likely would be present as a relatively thin, seasonal zone of saturation following periods of snowmelt or heavy precipitation. Perched groundwater is not believed to be regionally significant, but can serve as a source of recharge to the underlying bedrock aquifer system at the local level.

Distinct and generally localized hydrogeologic flow systems also can develop within mine waste areas such as constructed tailings impoundments. Dozens of these mine waste impoundment areas are present within the basin (Gross 1982; Morilla et al. 1975; Dames and Moore 1991), ranging from less than an acre to almost 200 acres in size. Two of the larger flotation tailing impoundments are the Central Impoundment Area (CIA) near Kellogg (approximately 190 acres) and Page Tailings Area near Smelterville (approximately 70 acres). The majority of these tailings impoundments are present within the South Fork Valley and its major tributaries. Groundwater, when present within these impounded mine wastes, shows varying degrees of hydraulic interaction with shallow alluvial aquifer systems that often underlie the impoundment areas. Where the mine waste materials are predominantly finer grained flotation tailings (e.g., Page tailing pile), groundwater mounding can occur. Morilla (1975) found that water levels in the regional alluvial aquifer beneath the tailings pile were not significantly affected by the groundwater mound within the pile due to the large differences in vertical hydraulic conductivity between the tailings and the underlying alluvial material. Other tailing impoundments containing predominantly coarser grained jig tailings may remain unsaturated year-round, or portions of the pile may be seasonally saturated and hydraulically interactive with a shallow alluvial aquifer system.

Similarly, large areas of the valley floors of Canyon Creek, Ninemile Creek, and the South Fork are blanketed with a variable thickness of tailings. The tailings were deposited over broad portions of the valley floodplain during flooding events that caused many tailings impoundment dams (i.e., coffer dams) to fail (Norbeck 1974; Houck and Mink 1994). These coarser grained deposits generally do not support the development of a separate groundwater flow system, but may become seasonally saturated and hydraulically connected with underlying alluvial aquifer systems during periods of high snowmelt and precipitation.

3.4.1.3.2 Alluvial Aquifer Systems. Three distinct groundwater flow regimes have developed within the unconsolidated alluvial/valley fill deposits. The alluvial materials are described below followed by a discussion of each of the three flow regimes.

Alluvial Materials. Unconsolidated sediments within the Coeur d'Alene valley include recent alluvium, glacial deposits, and older gravels and terrace gravels (Norbeck 1974) (see Part 1, Figures 3.2-1 and 3.2-2). These sediments tend to be fairly coarse grained in the eastern end of the South Fork valley, the upper portions of the North Fork, and in many of the larger, high gradient tributary valleys. For example, alluvial sediments in the east fork of Moon Creek were found to consist of very porous large cobbles and gravels mixed with sand and/or silt and clay, with a silt/clay unit present near the interface of the alluvium and underlying bedrock (Paulson and Girard 1996). In the western portion of the river basin downstream from Cataldo, the alluvial sediments become better sorted and finer grained. In the lower Coeur d'Alene River basin areas, the alluvial sediments consist predominantly of very fine sand, silt, and clay with some thin gravel layers. Within the delta of the Coeur d'Alene River, the upper 100 feet of the sediment column consist of silt, sandy silt, silty sand, and clay (Piske 1990).

Alluvial sediment thicknesses typically range from 10 to 30 feet in the tributary valleys, with greater thicknesses observed in the valleys of the North Fork, South Fork, and lower Coeur d'Alene River. Approximately 70 feet of alluvial valley sediments are present near Osburn, Idaho (MFG 1996), increasing to approximately 400 feet near Rose Lake, located 8 miles downstream from Cataldo, Idaho (Norbeck 1974). Electrical resistivity data presented by Norbeck (1974) for the Rose Lake area indicated two electrically distinct lithologic materials within the column of unconsolidated sediments: an upper 70-foot-thick layer of fine grained silt, sandy silt, and silty sand (resistivity 300 ohm meters), and a lower 345-foot-thick layer of silt and clay (resistivity 200 ohm meters). Near Cataldo, resistivity values for the upper layer were 600 ohm meters, indicating that the shallow alluvium consists of less conductive, and therefore more coarse-grained, granular material.

Upper-valley Alluvial System (CSM Unit 1). Shallow unconfined alluvial aquifers are present in many tributary valleys and the upper reaches of the South Fork and North Fork. These aquifers generally have a saturated thickness of less than 30 feet, consist of coarser grained, higher energy alluvial deposits (sands, gravel, cobbles, and boulders) and are underlain by nearly impermeable Belt Supergroup bedrock. This type of singular, unconfined aquifer was identified by MFG (1996) in their investigation of the Osburn area. Investigations of the lower Canyon Creek basin near Wallace, Idaho, by Houck and Mink (1994) also indicated the presence of a shallow, unconfined alluvial system. A strong degree of hydraulic interconnection often can exist between the unconfined alluvial aquifer system and the local surface water course (creeks or river). Studies by MFG (1996) and Houck and Mink (1994) described groundwater conditions that generally represent a single shallow unconfined alluvial aquifer and can serve as analogs for other similar aquifer systems that have developed within the larger tributary drainages of the South Fork, North Fork, and main stem of the Coeur d'Alene River.

Investigations of the shallow alluvial aquifer in Canyon Creek (Houck and Mink 1994) showed that the water table had a fairly steep horizontal hydraulic gradient, which generally followed the ground surface topography. Groundwater level data from the east fork of Moon Creek indicated a horizontal hydraulic gradient of approximately 0.10 ft/ft, similar to the gradient of the Moon Creek streambed (Paulson and Girard 1996). Steep horizontal hydraulic gradients also were inferred by Gross (1982) for the alluvial groundwater system in the lower reaches of Lake Creek basin near the Galena tailings impoundment. In the Milo Creek basin, Hunt (1984) observed steep vertical hydraulic gradients between a shallow alluvial aquifer and the underlying bedrock aquifer that had been dewatered by the underground workings of the Bunker Hill mine. Groundwater flow velocities within unconfined alluvial aquifers are expected to be moderately high, given the characteristically coarse-grained and permeable nature of the upper basin alluvial sediments, and the relatively steep hydraulic gradients.

Whether specific reaches of a creek or river are gaining or losing flow varies depending upon seasonal hydrologic conditions, and natural variations in the aquifer thickness and cross-sectional area. Other variables, such as the depth to groundwater, variations in the hydraulic conductivity of the alluvium, and seasonal changes in the hydraulic gradient, also can affect whether individual reaches are gaining or losing (MFG 1996). Surface water gains typically occur where the valley sediments become thinner and/or where the cross-sectional area of the aquifer becomes constricted, such as the valley of the South Fork west of Osburn (Norbeck 1974). Conversely, surface water losses occur where the valley sediments thicken or when the cross-sectional area of the aquifer increases.

Mid-valley Alluvial Aquifer System (CSM Unit 2). The alluvial aquifer system within the middle reaches of the South Fork and lower reaches of the North Fork is notably different from the alluvial aquifer system that is developed within the tributary valleys and upper reaches of the South Fork and North Fork. The following discussion of aquifer properties and groundwater flow patterns in this portion of the basin is taken in its entirety from the Maest et al. (1999) report titled *Expert Report: Release, Transport, and Environmental Fate of Hazardous Substances in the Coeur d'Alene River Basin, Idaho*.

> The groundwater system in the Coeur d'Alene river basin from Kellogg to the mainstem Coeur d'Alene River is divided into three hydrostratigraphic units: an upper alluvial zone, a middle lacustrine confining zone, and a lower alluvial zone (Dames and Moore 1991). The groundwater system along the mainstem Coeur d'Alene River is poorly understood. The upper and lower zones of the system from Kellogg to the mainstem are comprised of alluvium, while the middle confining zone consists of lacustrine silts and clays with low vertical and horizontal hydraulic conductivity (Dames and Moore 1991). The upper zone consists of jig and flotation tailings and alluvium underlain by natural alluvium and reaches thicknesses of 30-40 feet in eastern Smelterville Flats and the Pinehurst Narrows. The alluvium consists of silty to clayey sand and gravel with lenses of sand and gravel. Thicknesses of mixed tailings and alluvium are greatest (more than 7 feet) in the vicinity of the CIA and in central Smelterville Flats.
>
> The confining zone retards vertical groundwater flow between the upper and lower zones (Dames and Moore 1991). The confining zone is believed to pinch out beneath Kellogg between the mouths of Milo and Portal Gulches (Dames and Moore 1991). Thicknesses range from 0 feet near Kellogg to over 50 feet near Smelterville Flats. The lower zone is similar in composition to alluvium in the upper zone and is deposited on bedrock of the Belt Series rock. Unlike the upper zone, the lower zone is thickest (>50 feet) near Kellogg and thins westward. East of Kellogg, no confining zone exists, and the upper and lower alluvial units merge into one unconfined alluvial unit (Dames and Moore 1991).
>
> Upper zone groundwater flow is largely unconfined, though seasonal and local confinement may occur where overlying tailings are fine grained and in contact with the water table. The saturated thickness of the upper zone ranges from approximately 3 to 40 feet, thickening to the west (Dames and Moore 1991). During seasonal high water conditions, the bottom portion of the tailings deposits may become locally saturated (Dames and Moore 1991). Groundwater elevations

in the upper zone fluctuate seasonally and are recharged by precipitation and snowmelt. Groundwater levels are highest in the spring during periods of increased snowmelt and precipitation, and lowest during winter and early spring when precipitation rates are lowest and snowmelt is not occurring (Dames and Moore 1991).

Groundwater flow in the upper zone is predominantly east to west, with north-south flow near losing and gaining reaches of the South Fork Coeur d'Alene River and near mouths of tributary gulches (Dames and Moore 1991). Gaining and losing reaches are believed to be associated with variations in valley width. Where the valley widens, the water table falls below the river channel bed surface, and the channel loses water to the upper zone. Where the valley constricts, upper zone groundwater discharges to the river.

Hydraulic conductivity was highest in the upper zone, ranging from 500 – 10,790 ft/day and lowest in the confining zone, ranging from 0.00028 to 0.028 ft/day (Dames and Moore 1991). Hydraulic conductivity in the lower alluvial aquifer ranged from 100 – 1,910 ft/day. Transmissivity ranged from 10,002 – 216, 852 ft^2/day in the upper zone and 3,220 – 80,000 ft^2/day in the lower zone (Dames and Moore 1991).

Figures 3.4-1 and 3.4-2 present groundwater elevation contour maps generated by Dames and Moore (1991) for both the upper zone and lower zone aquifers within the immediate area of the Bunker Hill Superfund site.

The horizontal hydraulic gradient of the upper zone water table varied between 0.0043 ft/ft and 0.0046 ft/ft in 1988. The corresponding slope of the lower zone potentiometric surface varied from 0.0033 ft/ft to 0.0036 ft/ft during this same period (Dames and Moore 1991). The vertical hydraulic gradient between the upper zone and lower zone aquifers varies spatially, being predominantly downward in the area between Kellogg and Smelterville, and predominantly upward west of Smelterville. Figure 3.4-3 shows the relative direction of the vertical hydraulic gradients within the Bunker Hill study area. Head differentials of up to 5 feet exist across the confining zone and result in downward vertical hydraulic gradients as high as 0.20 ft/ft due west of Kellogg, and upward vertical hydraulic gradients as high as 0.10 ft/ft near the Pinehurst Narrows area.

Lower-valley and Delta Aquifer System (CSM Unit 3). Spruill (1993) summarizes the current understanding of groundwater conditions in the lower Coeur d'Alene Valley as follows:

> Hydrogeology of the lower Coeur d'Alene River Valley is not well understood. Little information is available on the extent and physical and hydraulic characteristics of the valley sediments. Most of the information on thickness of the valley sediments is from surface geophysical surveys…Lithologic descriptions from drillers' logs and logs presented in [Spruill's] report indicate that the valley sediments less than 35 feet below land surface are composed of silt and clay.

The hydrologic and wetland systems in the vicinity of the Cataldo Flats were investigated by Chamberlain and Williams (1998) to assess the role of natural wetlands in metals removal. The Cataldo Flats are covered by tailings and sediments that were deposited by, or dredged from, the Lower Coeur d'Alene River. Groundwater and surface water hydraulics as well as water quality were monitored. They reported that the floodplain and riverbank groundwater is recharged primarily by precipitation infiltration which is continuously dissolving large concentrations of cadmium, lead, and zinc out of the dredge spoils and into the river.

In the lower reaches of Coeur d'Alene River valley, downstream of Cataldo, the alluvial sediments become progressively finer and less transmissive as compared to the alluvial sediments upstream of Cataldo and the sediments within the higher elevation tributary valleys (Norbeck 1974). The shallow alluvial groundwater system consists mainly of thin water-bearing zones that are interspersed within the fine-grained, low-permeability sediments (Spruill 1993). These conditions give rise to a shallow water table aquifer that has a limited water production capacity.

The presence of many lakes and wetland areas in the lower reaches of the Coeur d'Alene River Valley suggests that a dynamic hydraulic interrelationship exists between these surface water bodies, the river, and the shallow alluvial groundwater system. Most recharge to the shallow groundwater system occurs via direct infiltration of precipitation and/or during high river runoff and flooding events (Spruill 1993). Groundwater is essentially "trapped" for long periods of time in the low-permeability valley sediments, and therefore does not readily exchange with either the river or nearby lakes (Spruill 1993). As a result, the groundwater in these fine-grained deposits occasionally can become highly mineralized.

Horizontal hydraulic gradients in the lower valley can be very low. For the Killarney Lake area, Spruill (1993) estimated the groundwater flow velocity in the fine-grained valley sediments to be less than 10^{-4} feet/day, based on (1) slug test-derived values of hydraulic conductivity (average of

0.03 feet/day), (2) an hydraulic gradient of 0.0015, and (3) an assumed effective porosity of 40 percent. The shallow groundwater system in the flat-lying Coeur d'Alene River delta shows an even lower average horizontal hydraulic gradient of 0.00004 (Piske 1990).

Little or no data currently are available to assess the hydraulic connection between the valley sediments and the underlying bedrock.

3.4.1.3.3 Bedrock Aquifer Systems

Lithologic and Structural Controls. The predominant bedrock type within CSM Units 1, 2, and 3 consists of faulted and fractured metasedimentary rocks of the Belt Supergroup. Consequently, fracture flow is the most important component of groundwater flow in the bedrock aquifer system. The quartzites and argillites of the Belt Supergroup have characteristically low values of primary intergranular and intercrystalline hydraulic conductivity. Secondary hydraulic conductivity (which may include faults, joints, bedding planes, and other fracture features) may be several orders of magnitude higher than the primary hydraulic conductivity.

The orientation of spatially continuous, permeable fractures or fracture zones likely exerts a strong, if not dominant, hydraulic control over regional groundwater flow within the bedrock aquifer system. Fault zones, for example, often exhibit a much higher permeability than the surrounding unfractured rock mass. These large scale structures, in particular, are believed to represent the highest degree of fracturing. However, depending upon the degree of displacement (i.e., offset) that occurred along the fault, the fault zones also can show a localized region of low-permeability, fine-grained material (i.e., gouge) produced by the grinding and shearing action within the fault plane. Where low permeability gouge zones exist, they can restrict horizontal flow across the faults, promoting preferential flow parallel to the fault zone (Demuth 1991).

Flow System Characteristics. Much of the interior portions of the basin consists of steep, mountainous terrain. Groundwater flow within steep mountain basins has been simulated by Toth (1963) and Freeze and Witherspoon (1967). The well-defined relief, coupled with an expected near-surface concentration of fracture features, is expected to favor the development of relatively short to moderate length groundwater flow systems within the larger tributary watersheds. A general summary of anticipated hydraulic controls on groundwater flow within a steep mountain basin (Hunt 1984) prior to mining is provided below:

- Topographic divides are groundwater divides.
- Peaks, ridges, and upper mountain slopes are areas of recharge.

- Valleys or lower mountain slopes are areas of groundwater discharge.
- Groundwater flow velocities decrease with depth.
- Secondary openings resulting from fracturing and faulting are the only significant source of natural hydraulic conductivity.

These concepts were found to be consistent with hydrologic observations by Gaillot (1979) in the steep alpine setting of the Jack Waite Mine (East Fork Eagle Creek Basin), and by Hunt (1984) for the Bunker Hill Mine area near Kellogg, Idaho.

Hydraulic Influence of Underground Workings. Many areas within the Coeur d'Alene River watershed, most notably within the South Fork, have been host to underground mining activities. These mining activities can alter the natural hydrogeologic conditions within the surrounding bedrock aquifer system. Extensive networks of underground workings serve as new groundwater flow pathways and create new points of groundwater discharge. Unflooded mine workings can dewater fracture flow systems and then discharge from adits or other mine openings by gravity drainage or pumping. The removal of water from the mine results in gradually expanding zones of desaturation until a situation of dynamic hydraulic equilibrium is reached (Hunt 1984). The dewatering of the fractured bedrock system by the underground workings can result in the development of a localized cone of depression and creation of an unsaturated zone in the bedrock above the mined out areas. Hydraulic alterations of the kind described above have been documented around the Bunker Hill Mine near Kellogg and likely occur around many other mine sites in the Coeur d'Alene River basin where underground mining methods were employed.

Bedrock Aquifer Parameters. Few studies have attempted to quantify the hydraulic conductivity of the fractured bedrock aquifer within the Coeur d'Alene River basin. Best-fit values of bedrock hydraulic conductivity of 0.04 ft/day for the bedrock blocks and 4 ft/day for the faults were applied by Frankel (1986) in the development of a three-dimensional, finite-difference model of the Bunker Hill Mine. These values were felt to be very speculative. Lachmar (1989) derived average hydraulic conductivity values of 10^{-1} to 10^{-2} ft/day for quartzites of the Revett Formation within a portion of the Bunker Hill Mine based on numerical model calibration and aquifer parameter estimations from constant discharge flow tests. Other numerical modeling by Lachmar (1989) suggested, however, that the hydraulic conductivity in "wet" and "dry" portions of the Bunker Hill Mine study area could differ by two to three orders of magnitude. Research by Morrow et al. (1984) has shown that the hydraulic conductivity of the gouge in fault zones can be extremely low, on the order of 10^{-10} ft/day.

3.4.1.4 Groundwater-Surface Water Interactions

Interactions between groundwater and surface water occur in many portions of the basin. These were documented between Kellogg and Pinehurst Narrows as part of the Bunker Hill Superfund investigations (Dames and Moore 1991). More recently, the USGS conducted studies of surface water-groundwater interaction in Canyon Creek and along the South Fork in the Osburn Flats and Smelterville areas (USGS 2000). Surface water can act as a pathway to shallow alluvial groundwater that, in turn, can recharge to downgradient surface waters. Groundwater-surface water interactions are evident in gaining and losing sections of the South Fork as seasonal and perennial seeps, and during seasonal flooding and subsequent receding of floodwaters (Stratus 2000).

Dissolved metals are leached into the underlying floodplain aquifer by percolating rainfall and snowmelt or rising groundwater. The permeable floodplain aquifer rapidly routes water from losing stream reaches (where the valley floor widens) to gaining stream reaches (where the valley narrows), efficiently transferring dissolved metals from floodplain soils to the stream (Stratus 2000).

For groundwater in the lower Coeur d'Alene River basin near Killarney Lake, a small but quantifiable amount to groundwater flows to the river as river stage drops. However, as the river rises and falls, the shallow groundwater system, particularly the upper few feet, is constantly undergoing mixing of river water or precipitation with water moving downward from the previous occurrence of recharge (Spruill 1993).

3.4.2 Hydrogeology—CSM Units 4 and 5

3.4.2.1 Groundwater Usage

Groundwater serves as the primary potable water supply source for most rural residents within CSM Unit 4, exclusive of the City of Coeur d'Alene. Only a limited number of municipal and community water supply wells are known to be present. Near the mouth of the Coeur d'Alene River on the east side of Coeur d'Alene Lake, the City of Harrison obtains its potable water from municipal wells that are completed into basalt flows of the Columbia River Group. Well inventory information from Piske (1990) indicated a reported test yield of 235 gpm from one City of Harrison well. Community water supply wells from the Rockford Bay area on the west side of Coeur d'Alene Lake produce low quantities of groundwater (typically less than 10 gpm) from metasedimentary schist and gneiss (generally referred to as "granite" on drillers' logs).

Groundwater also serves as the primary water supply source for domestic, commercial, and industrial uses by the City of Coeur d'Alene, the City of Post Falls, and the City of Spokane. Well yields of up to 10,000 gpm have been reported from larger municipal and irrigation wells that are completed into the coarse, permeable glaciofluvial sand and gravels of the Rathdrum Prairie and Spokane Valley aquifer system. Groundwater withdrawals from high-capacity wells operated by municipalities and water purveyors throughout the Rathdrum Prairie and Spokane Valley areas represent the largest proportion of groundwater usage from the aquifer system.

3.4.2.2 Monitoring Well Networks

Unlike CSM Units 1, 2, and 3, few hydrogeologic investigations or contaminant studies are known to have been performed in the immediate vicinity of Coeur d'Alene Lake. Little or no information was found regarding the presence of monitoring wells and/or piezometers within CSM Unit 4 that could be used to support potential future RI sampling or water level monitoring. Information on near-lake groundwater quality or water levels could possibly be obtained from domestic water supply wells.

A fairly extensive array of groundwater monitoring wells (including some domestic water supply wells) are located throughout portions of the Rathdrum Prairie aquifer and Spokane Valley aquifer away from the lake. A sizable number of these monitoring wells have been installed by Spokane County and the City of Spokane to support regional water quality evaluations and wellhead protection activities. Other monitoring wells have been installed by the USGS to support various water resource and water quality studies. An extensive body of water quality and water level data has been collected from this network of monitoring wells and from the municipal water supply wells.

3.4.2.3 Hydrogeologic Overview (CSM Unit 4)

Over most of its extent, Coeur d'Alene Lake is a regional groundwater discharge zone. However, at its northernmost end, the lake is a primary source of recharge into the Rathdrum Prairie aquifer. Localized groundwater flow systems around the flanking edges of Coeur d'Alene Lake can be divided broadly into three categories: (1) groundwater flow through naturally fractured metasedimentary bedrock (e.g., Belt Supergroup quartzites, argillites, schists and gneisses), (2) groundwater flow through basalt of the Columbia River Group, and (3) unconsolidated alluvial deposits within localized drainages (Cougar Creek, Mica Creek, Cedar Creek and Lake Creek) that discharge to Coeur d'Alene Lake.

3.4.2.3.1 Alluvial Aquifer Systems. Geologic mapping by Griggs (1973) indicated that several local drainages that discharge into Coeur d'Alene Lake (Cedar Creek, Cougar Creek, Mica Creek, and Lake Creek) contain recent alluvium (Griggs 1973). No information was found regarding the thickness or lithologic characteristics of the alluvial sediments, outside of the Coeur d'Alene River delta. The alluvial sediments in these tributary drainages are expected to be relatively thin (less than 30 feet thick) and likely consist of coarser grained, higher energy deposits (sands, gravel, cobbles and boulders). Localized groundwater flow systems may develop within these alluvial sediments, where these drainages receive groundwater discharge from the surrounding bedrock units and/or where losing stream reaches occur.

Within the delta of the Coeur d'Alene River (western end of CSM Unit 3), the upper 100 feet of the sediment column consist of silt, sandy silt, silty sand, and clay (Piske 1990). Due to their fine-grained nature, only negligible quantities of groundwater were observed to discharge from these deltaic alluvial sediments.

3.4.2.3.2 Columbia River Group Basalt. Basalt of the Columbia River Group is present around much of the near-shore upland area of Coeur d'Alene Lake (Griggs 1973). Whiteman et al. (1994) indicated that both Wanapum and Grande Ronde basalt units are present in the Coeur d'Alene Lake area. A well inventory by Piske (1990) included several wells in the lower Coeur d'Alene River Basin east and southeast of Harrison that were completed in basalt. Well logs for the city of Harrison, Idaho show that basalt occurs to a depth of at least 275 feet below lake level (Piske 1990). The basalt flows are described as pillow-palagonite tuff complexes that occasionally are found interspersed with outcrops of the Belt Supergroup rocks. The hydraulic characteristics and groundwater flow conditions within these layered extrusive rocks are expected to differ from the Belt Series Supergroup rocks; in particular, primary water-bearing zones within the basalt sequence typically occur at the rubbly, brecciated interface between successive flows (interflow zones). Hydraulic conductivity within these interflow zones can be relatively high, whereas hydraulic conductivity within the more massive flow interiors can be several orders of magnitude lower.

3.4.2.3.3 Fractured Metasedimentary Bedrock Aquifer

Lithologic and Structural Controls. Faulted and fractured metasedimentary rocks of the Belt Supergroup are a predominant bedrock type within CSM Units 4, and similar in kind to those found in CSM Units 1, 2, and 3. Consequently, fracture flow is the most important component of groundwater flow in this bedrock aquifer system. The quartzites and argillites of the Belt Supergroup have characteristically low values of primary intergranular and intercrystalline hydraulic conductivity. Secondary hydraulic conductivity (which may include faults, joints, bedding planes, and other fracture features) may be several orders of magnitude higher than the primary hydraulic conductivity. The orientation of spatially continuous, permeable fractures or fracture zones likely exerts a strong hydraulic control over localized groundwater flow within the bedrock aquifer system in the immediate vicinity of Coeur d'Alene Lake. However, local flow systems that develop in the near-shore upland area around the lake also will be influenced by topographic controls in mountainous terrain, as described previously for CSM Units 1, 2, and 3.

A hydrogeologic investigation of the Kootenai County Landfill (CH2M HILL 1999) near Rockford Bay (west side of Coeur d'Alene Lake) indicated that groundwater flow through metasedimentary schist and gneiss generally follows the surface topography under a fairly steep horizontal hydraulic gradient ranging from 0.05 to 0.11 ft/ft. Groundwater transmission through the bedrock groundwater unit at the landfill was thought to be controlled both by movement through closely spaced fractures in the competent gneiss unit and through the highly weathered schist whose lithologic characteristics approached a quasi-granular porous media.

Hydraulic Parameters. Few studies have attempted to quantify the hydraulic conductivity of the fractured bedrock aquifer within CSM Units 1 through 4. Section 3.4.1.2 presents a discussion of hydraulic conductivity estimates presented for Revett Formation quartzites near Kellogg, Idaho. Slug tests conducted in the schist unit at the Kootenai County landfill by Parameterix (1991) yielded hydraulic conductivities of approximately 0.8 ft/day (based on an assumed aquifer thickness of 5 feet).

3.4.2.4 Hydrogeologic Overview (CSM Unit 5)

CSM Unit 5 includes the Spokane River, from CdA Lake to the Highway 25 bridge at the Fort Spokane confluence with the Columbia River at Lake Roosevelt. A large number of hydrogeologic investigations and studies have occurred in the upper reaches of the river basin above Long Lake where an areally extensive and highly productive glacial outwash aquifer system (the Spokane Valley/Rathdrum Prairie Aquifer) is present. This aquifer is the major source of drinking water for the cities of Spokane, Post Falls, and Coeur d'Alene, and for residents within the Spokane Valley area. Information on hydrogeologic conditions in the lower reaches of the Spokane River basin, from Long Lake to Lake Roosevelt, is much more limited. The Spokane Valley/Rathdrum Prairie Aquifer is the dominant groundwater unit in this portion of the RI study area and is the primary focus of this discussion. Other groundwater systems, however, also have developed in the upland bedrock areas that flank the Spokane River Valley—especially within the basalts of the Columbia River Group.

3.4.2.4.1 Glacial Outwash Aquifer. The primary aquifer system in the upper and middle segments of CSM Unit 5, from Coeur d'Alene Lake to Long Lake, is the Spokane Valley-Rathdrum Prairie aquifer. Glaciofluvial deposits form the aquifer material and are composed predominantly of poorly to moderately sorted sand and gravel, with lesser amounts of silt, clay, cobbles and boulders (Sagstad 1977). These unconsolidated sediments were deposited during several major catastrophic flood events collectively known as the Spokane floods, which spread across the Rathdrum Prairie and Spokane Valley and scoured the Channeled Scablands of eastern Washington during the Pleistocene Epoch (Ecology and Environment 1995). The glaciofluvial deposits are as much as 500 feet thick in portions of the Spokane Valley, based on limited deep well and geophysical data. The grain size of the sand and gravel materials generally increases away from the valley margins. The aquifer is underlain and flanked by pre-Tertiary granitic and metasedimentary rocks, fine-grained sediments of the Latah Formation, and/or basalts of the Columbia River Group.

Groundwater in the Spokane Valley-Rathdrum Prairie aquifer system occurs under unconfined (water table) conditions. From the Spokane River outlet of Coeur d'Alene Lake to the middle of the Spokane Valley, the aquifer system is not in direct hydraulic communication with the Spokane River, but does receive recharge due to seepage losses from the river bed. From the central portion of the Spokane Valley to the Nine Mile Dam area, the Spokane River and aquifer system become hydraulically coupled, resulting in a dynamic interaction between surface water and groundwater that is influenced by seasonal groundwater elevations and changes in river stage.

Two surface water drainages, Latah Creek and the Little Spokane River, are directly tributary to the Spokane River upstream of Long Lake. Some groundwater throughflow from the Latah Creek basin does serve as recharge to the Spokane Valley aquifer. Other streams such as Chester Creek and Saltese Creek, and surface water drainage from Newman Lake and Liberty Lake, percolate into the coarse and permeable sediments along the margins of the Spokane Valley before reaching the Spokane River and provide additional recharge to the aquifer.

3.4.2.4.2 Water Levels, Hydraulic Gradient, and Direction of Groundwater Flow. Groundwater contour maps for the eastern, central, and western portions of the Rathdrum Prairie-Spokane Valley Aquifer are presented in Figures 3.4-4, 3.4-5 and 3.4-6, respectively (Sagstad 1977; CH2M HILL 1998; CH2M HILL 2000). Groundwater flow direction in the aquifer is generally northward just north of Coeur d'Alene Lake and northwestward and westward through the Spokane Valley. The pattern of groundwater contour lines shows that Coeur d'Alene Lake and the Spokane River both actively recharge the aquifer system. West of the state line, the aquifer receives additional recharge from seasonal surface water runoff from adjoining tributaries.

The northward flow of groundwater from the Coeur d'Alene area and the southward flow of groundwater from the northern part of the Rathdrum Prairie converge northwest of Coeur d'Alene and flow westward through the Spokane Valley (Ecology and Environment, Inc. 1995). West of Post Falls, Idaho, groundwater flow tends to parallel the axis of the valley and the direction of flow in the Spokane River. The depth to groundwater varies from 150 to 200 feet in the Rathdrum Prairie and the vicinity of the state line, to less than 40 feet in areas close to the river in the Spokane Valley reaches. The horizontal hydraulic gradient varies from 0.005 ft/ft near Coeur d'Alene Lake to 0.001 ft/ft in the central Spokane Valley area.

As shown on Figure 3.4-6, near downtown Spokane the aquifer system splits into two separate segments. Most of the groundwater moves northward through the Hillyard Trough and eventually discharges to the Little Spokane River. The western segment of the Spokane Valley aquifer continues downstream of Spokane Falls to the Nine Mile Falls dam, and displays a close hydraulic interaction with the Spokane River. A steep hydraulic gradient also is observed in a narrow, localized trough-like feature (Trinity Trough) that hydraulically connects the two separate aquifer segments. Similarly, the horizontal hydraulic gradient steepens at the north end of the Hillyard Trough where the Spokane Valley aquifer discharges to the Little Spokane River.

Groundwater levels in the aquifer fluctuate seasonally by as much as 10 to 15 feet in response to spring recharge, changes in the stage of the Spokane River, and seasonal variations in groundwater withdrawal. In the Rathdrum Prairie area and the eastern half of the Spokane Valley, groundwater fluctuations are not as strongly influenced by precipitation and changes in river stage as is observed in the western half of the Spokane Valley aquifer system.

3.4.2.4.3 Hydraulic Parameters. Estimates of aquifer hydraulic conductivity and transmissivity have been derived from completion of single well and multiple-well pumping tests conducted at several locations throughout the aquifer (CH2M HILL 1998 and 2000). Aquifer transmissivity values typically range from 500,000 to 3,000,000 ft^2/day for the main portions of the Rathdrum Prairie and Spokane Valley aquifer system. Corresponding estimates of hydraulic conductivity typically range from 500 to 5000 ft/day. Lower values for transmissivity and hydraulic conductivity generally are associated with finer grained materials deposited in closer proximity to the valley margins, while higher values are present in the central portions of the valley.

3.4.2.4.4 Long Lake Area. Hydrogeologic conditions in the lower Spokane River basin downstream of Nine Mile Falls, including Long Lake and the reach of the Spokane River downstream of the Long Lake dam, are not well documented. Information from Griggs (1973) indicates that glaciofluvial and alluvial deposits are present in the valley floodplain. The thickness of these unconsolidated valley fill deposits is not known. It is expected that unconfined groundwater conditions exist in these materials. The valley is flanked and likely underlain by Tertiary-age granitic rocks. Groundwater from basalts of the Columbia River Group also is expected to discharge as springs and/or underflow into the valley alluvium. The nature and dynamics of hydraulic interactions between the river (Long Lake reservoir) and the surrounding glaciofluvial deposits are not known.

3.5 SURFACE WATER HYDROLOGY

This section presents a summary of the surface water hydrology of the Coeur d'Alene River basin, Coeur d'Alene Lake, and the Spokane River. Hydrology is the branch of physical geography that is concerned with the origin, distribution, and properties of the waters of the earth. In addition to a general discussion of hydrology, the available data and methods used to describe the hydrology are discussed. Specific discussions of individual watersheds are presented in Parts 2 through 6. The study area extends from the Idaho-Montana border to the confluence of the Spokane and Columbia Rivers.

3.5.1 Introduction

Precipitation in the form of rain or snow provides the ultimate source of surface water in the study area. Average annual precipitation in the study area varies from about 18 inches at the Spokane Station to more than 37 inches at Wallace (WRCC 2000). This water flows off of hillslopes, seeps into the soil, is evaporated, or may be used by vegetation for growth. When water flows overland and through channels, sediment and dissolved minerals can become incorporated into the flow. These mechanisms are discussed in other sections. Once entrained in the flow, surface water is the major transport mechanism of moving sediment or dissolved materials. In addition to incorporating sediment and dissolved constituents, surface water can remobilize sediment stored in the banks and channel bottom by scouring and eroding riverbanks.

The Coeur d'Alene River basin is situated in the western portion of the Bitterroot Mountain Range in Northern Idaho with the headwaters in the mountainous regions and the mouth at Coeur d'Alene Lake. In general, the river channel flows east to west with tributary channels entering from more northerly or southerly orientation. The overall basin size is approximately 1,475 square miles with 810 miles of mapped channel. The drainage density ranges from approximately 0.4 to 1.0 mile per square mile and is relatively constant throughout the system.

The average annual discharge, or stream flow rate, at Harrison, near the mouth of the Coeur d'Alene River at Coeur d'Alene Lake, is approximately 2,600 cubic feet per second, with summer base flow (dry weather flow attributed to groundwater discharge to surface water) of approximately 500 cubic feet per second. Maximum mean daily discharge for the period of record, 1991 through 1999, has been modeled at 66,793 cubic feet per second (USGS 2000a).

Although Coeur d'Alene Lake is a natural water body, the water surface elevation and discharge from the lake to the Spokane River is regulated by the Post Falls Dam. Average annual discharge downstream of the Post Falls Dam is approximately 2,900 cubic feet per second with summer base flow on the order of 1,700 cubic feet per second. Maximum mean daily discharge for the period 1991 to 1999 was 42,300 cubic feet per second (USGS 2000b). These discharges are controlled by complex relationships between inflow from the tributary channels, evaporation, and regulation of water level and storage within the lake by the Post Falls Dam. In addition to the Coeur d'Alene River, Coeur d'Alene Lake is fed by several other drainages most notably: St. Joe River (largest tributary to the Lake), Wolf Lodge Creek, Carlin Creek, Plummer Creek, and Fighting Creek. These tributaries are not discussed in this section.

The study area is divided into five CSM Units as presented in Section 2. In general, similar hydrologic and sediment transport mechanisms occur within each CSM Unit. There is some overlap in mechanisms; however, these divisions are adequate for this discussion. Specific mechanisms and regimes are discussed for individual watersheds in Parts 2 through 6. An overview of these mechanisms and regimes is presented in the following sections.

3.5.1.1 CSM Unit 01—Upper Watersheds

The topography of the upper watersheds and tributary streams of the Coeur d'Alene River consists of mountains of the Bitterroot Range over 6,000 feet high. High gradient stream channels carry surface water down through the watersheds. These areas include: Prichard Creek, Beaver Creek, Canyon Creek, Ninemile Creek, Big Creek, Moon Creek, Pine Creek, and the South Fork above Wallace. Precipitation falling in these areas during the fall and winter often occurs as snow and does not flow directly into the channels. This snow is stored until melted by warmer weather in spring and summer when the snow-melt water flows into the channels and through the system. Precipitation occurring in these areas in spring and summer may also fall as snow; however, warmer temperatures in these seasons favor precipitation falling as rain. The rainfall during these seasons flows off into the channels or may infiltrate into soil or cracks in bedrock and recharge groundwater. These areas typically have low discharge in the stream channels in the fall and winter. The largest discharges in the upper watershed (high-flow events) occur in spring as the snow in the mountains melts. Stream channel discharges typically decrease through the summer (low-flow events) as the snow pack is depleted. Occasionally, warm periods during the winter will produce rain, which, coupled with melting snow, will flow directly into channels and produce very large magnitude discharges.

Due to the high gradient (slopes greater than about 4 percent) and often confined channels, these areas have limited capacity to store sediment; therefore, these areas produce much of the sediment transported by the system overall. Some sediment storage is possible in areas where there is a developed floodplain in contact with the stream channel, or areas where bars may develop. Sediment is generally incorporated and transported by these streams as bedload (larger particles that travel along the bottom of the channel) or suspended load (smaller particles that travel in the flowing water) during the high-flow stream discharges during spring and summer snowmelt. The quantity of sediment transport typically increases as stream discharge increases, as does the particle size moved. Even during low-flow conditions, some sediment transport occurs as very fine particles that are kept in suspension by moving water. Sediment sources in these channels typically are bank erosion, channel migration, bed material remobilization, and sediment derived from debris deposits adjacent to stream channels.

3.5.1.2 CSM Unit 02—Midgradient Segments 1 Through 3

The midgradient portion of the basin includes the South Fork from Wallace to Pinehurst and the North Fork. The topography of the midgradient portion of the basin is typified by medium-gradient stream channels (slopes about 2 to 4 percent) with alluvial floodplains. Many of the riverbanks in this area have been armored or protected from erosion with vegetation, embankments, barbs and weirs, particularly on the South Fork. Similar discharge patterns occur in these channels compared with the upper watershed channels, with maximum annual discharge typically occurring in spring as a result of snowmelt. However, high-flow events may occur in fall and winter due to lower elevations having a greater portion of precipitation occurring as rain. Rain on snow events are also more likely in these areas due to the lower elevation. The magnitude of the fall and winter discharges with respect to the spring snow melt discharge increases downstream. Again, this is likely due to the lower elevations where less precipitation is stored as snow throughout the winter.

Due to the connection of the channels with the floodplain in areas with lower gradients, more sediment may be stored in the midgradient streams than in the upper watershed. In areas where the channel has not been channelized or banks protected, the channels often display a meandering and braided channel form. Wetlands are also developed in areas of lower river gradients and channel braiding. These braided channels may deposit sediment in one area, while incorporating sediment from another area. As with the upper watershed channels, the quantity of sediment transported, as well as the particle size, increases at larger stream discharges but some sediment transport likely occurs at low discharges. Sediment sources in these channels are typically from bank erosion, channel migration, channel bed material remobilization, and sediment from the upper watersheds and tributary streams.

3.5.1.3 CSM Unit 02—Midgradient Segment 4, and CSM Unit 03—Lower Coeur d'Alene River

The topography of the lower portion of the watershed consists of a broad floodplain with numerous lakes and wetlands adjacent to the channel. The gradient of the channel is very low (slopes less than 2 percent). This area consists of the Coeur d'Alene River from the mouth at Coeur d'Alene Lake to the confluence of the North and South Forks. Maximum annual discharge typically occurs in the spring as a result of snowmelt; however, due to the lower elevation and more precipitation occurring as rain, larger discharges may occur during the fall and winter with respect to the spring discharges. The many wetlands, lakes and broad floodplain in this section of the river provide abundant storage for storm water. These areas store water during large discharges, attenuating peak discharges at downstream locations. These wetlands and lakes have complex hydrologic connections to the river that are controlled by natural channels, dredged channels, dikes, culverts and groundwater connections.

Due to the low gradient, this section of the river channel does not transport appreciable amounts of gravel; however, sand and silt are transported. Storage for sediment occurs in the broad floodplain, wetlands and lakes adjacent to the channel. The quantity of sediment transported increases at higher discharges, with some sediment load transported at even the lowest discharges. Sediment sources in the river include bank erosion, channel bed remobilization and sediment from the upper watershed, tributary channels, and the mid gradient sections. Channel migration does not appear to be a significant source of sediment as the channel alignment has been relatively constant through time.

3.5.1.4 CSM Unit 04—Coeur d'Alene Lake

The Coeur d'Alene River discharges into Coeur d'Alene Lake. Coeur d'Alene Lake covers approximately 70 square miles. The lake is also fed by several tributary streams, including: St. Joe River (largest tributary to the Lake), Fighting Creek, Plummer Creek, Wolf Lodge Creek and Carlin Creek. Discharge from Coeur d'Alene Lake to the Spokane River is controlled by the

Washington Water Power Company dam at Post Falls, ID. This dam is generally operated for power production and water storage for power production at downstream dams. This regulation at Post Falls controls lake elevation and discharge to the Spokane River. Drawdown of the lake begins in mid September. The water is slowly lowered to approximately 2,122 feet by January, then allowed to recede at its natural rate of outflow (Wyman 1993).

Little sediment is transported through Coeur d'Alene Lake. The majority of sediment is deposited as deltas at the mouth of each tributary. Most of the fine particles carried in by the Coeur d'Alene River are deposited in the lake; however, fine-grained particles are carried from the lake to the Spokane River, especially during high-flow flood events.

3.5.1.5 CSM Unit 05—Spokane River

The Spokane River is the only surface outlet of Coeur d'Alene Lake, and above Post Falls Dam the river is essentially an extension of the lake during much of the year. The lake is maintained at a normal summer elevation of 2,128 feet (Wyman 1993). According to the Washington Water Power (WWP) Company, drawdown of the lake and river begins in mid September. The water is slowly lowered to approximately 2,122 feet by January, then allowed to recede at its natural rate of outflow. From January until the end of spring snowmelt and runoff, the Spokane River acts as a free flowing stream. WWP then resumes control of the water levels for the remainder of the year.

Channel configurations at seven locations along the river were summarized by Wyman (1993). The Spokane River is generally shallow, warm and well oxygenated; however, deep pools which exist near Ford Rock and above Post Falls Dam may contain cooler, oxygen deficient water during the summer months.

The median discharge at the lake outlet, from 71 years of record (1913 to 1983), is 2,900 cfs, with 90 percent of the recorded flow rates between 1,500 and 6,420 cfs (Wyman 1993). The flow rate of the river at Post Falls is slightly less at 2,730 cfs with 90 percent between 1,340 and 6,280 cfs (Wyman 1993). The difference in flow is most likely due, in part, to leakage from the river to the Rathdrum aquifer (Wyman 1993).

The recorded low flow outflow and recurrence interval (given in parentheses) from Coeur d'Alene Lake is 2,900 cfs (2 years), 2,070 cfs (5 years), 1, 650 cfs (10 years), and 1,500 cfs (20 years) (Wyman 1993). Recurrence interval is the average number of years within which a given event will be equaled or exceeded.

The Spokane River is noted for its lack of fine sediments and its "armored" surface. Fine-grained, metal-laden sediments are unlikely to be deposited on the tightly packed, coarse gravels that make up the river bed throughout its shallow reaches (Wyman 1993). Very few sediments accumulate in the Spokane River channel, however, because the river carries very little suspended sediment at low flow. Sediments would most likely be deposited in the river at low flow and scoured out at high flows. Most of the fine particles carried in by the Coeur d'Alene River are probably deposited in the lake before the water exits via the Spokane River. Several deep reaches of the Spokane River are probably less scoured by the current and may be zones of accumulation of fine sediments (Wyman 1993).

3.5.2 Hydrology Evaluation Approach

This section describes the data sets and methods used to describe the surface water hydrology of the study area. The data sets and methods described in this section provide a framework from which the hydrology of the individual watersheds were analyzed. The hydrology of each watershed segment is described in detail in the individual surface water hydrology sections. Discussion in these sections includes numerical analyses of maximum and minimum discharge magnitudes, calculation of discharge of specified recurrence interval flows, discussion of historical and recent gage data, and discussion of unique processes and characteristics of each basin.

In addition to the surface water hydrology sections, the physical transport sections provide discussion of mechanisms and processes important to sediment transport in each watershed segment. Analyses of aerial photographs and topographic maps were completed to further identify areas supplying sediment or storing sediment in the system. These individual physical transport sections provide discussions concerning areas and channel reaches where stabilization and restoration efforts may be appropriate. These sections also present sediment yield of each watershed and analyses of grain size mobility based on the USGS sediment transport data collected during water year 1999.

3.5.2.1 USGS Stream Flow and Water Quality Monitoring Network

In support of the RI/FS, the United States Geological Survey (USGS) designed and operated a stream flow and water quality monitoring network for water year 1999. Water year 1999 ran from October 1, 1998, through September 30, 1999. Stream monitoring stations were established at 19 locations in the basin, upgradient of Coeur d'Alene Lake. River stage (surface water elevation) data were collected from 12 of these monitoring stations. Unique stage-discharge relationships were then developed for each station by the USGS and stream discharge was calculated. Two of these stations occur in the backwater created by Coeur d'Alene Lake, as such, a valid stage-discharge relationship was not developed. For these two monitoring stations, discharge was computed by the USGS using the stream-flow model FourPt (designated with a double asterisk on the list below). For five of these monitoring stations, discharges were computed by the USGS by correlating discharge measurements to nearby continuous stream-flow stations, thus creating synthetic hydrographs (designated with a single asterisk on the list shown below). A hydrograph is a plot of stage (e.g., elevation) or discharge (e.g., flow rate) vs. time. Mean daily discharges at each of the monitoring stations were used to characterize the surface water hydrology of a watershed. The names and locations of the monitoring stations are listed below (USGS 2000a and 2000c):

- 12413040, South Fork above Deadman Gulch near Mullan, Idaho
- 12413150, South Fork at Silverton, Idaho
- 12413210, South Fork at Elizabeth Park near Kellogg, Idaho
- 12413470, South Fork near Pinehurst, Idaho
- 12413125, Canyon Creek above mouth at Wallace, Idaho
- 12413123, Canyon Creek at Woodland Park, Idaho*
- 12413118, Canyon Creek near Burke, Idaho
- 12413130, Ninemile Creek above mouth at Wallace, Idaho
- 12413127, East Fork Ninemile Creek above mouth near Blackcloud, Idaho*
- 12413140, Placer Creek at Wallace, Idaho
- 12413190, Moon Creek above mouth at Elk Creek, Idaho*
- 12413290, Government Gulch Creek near mouth at Smelterville, Idaho*
- 12413445, Pine Creek below Amy Gulch near Pinehurst, Idaho
- 12411000, North Fork above Shoshone Creek near Prichard, Idaho
- 12411935, Prichard Creek above mouth at Prichard, Idaho
- 12413000, North Fork at Enaville, Idaho
- 12413500, Coeur d'Alene River at Cataldo, Idaho
- 12413500, Coeur d'Alene River at Rose Lake, Idaho**
- 12413860, Coeur d'Alene River at Harrison, Idaho**
- 12419000, Spokane River near Post Falls
- 12422500, Spokane River near Spokane
- 12433000, Spokane River at Long Lake

In addition to the data collected for water year 1999, some of these USGS monitoring stations had been monitored previously. For the stations listed below, data are available for instantaneous peak and mean daily discharge for the period listed. Mean daily discharge data were only available for the Coeur d'Alene River locations at Rose Lake and Harrison (USGS 2000a and 2000b).

- 12413210, South Fork at Elizabeth Park near Kellogg, Idaho, 1974-1982
- 12413150, South Fork at Silverton, Idaho, 1968-1988, 1999
- 12413470, South Fork near Pinehurst, Idaho, 1988-1999
- 12413140, Placer Creek at Wallace, Idaho, 1968-1996, 1999
- 12411000, North Fork above Shoshone Creek near Prichard, Idaho, 1950-1999
- 12412000, North Fork Near Prichard, 1945-1953
- 12413000, North Fork at Enaville, Idaho
- 12413500, Coeur d'Alene River at Cataldo, Idaho, 1911-1999
- 12413500, Coeur d'Alene River at Rose Lake, Idaho, 1991-1999 (FourPt modeling)
- 12413860, Coeur d'Alene River at Harrison, Idaho, 1991-1999 (FourPt modeling)

The USGS also collected bedload and suspended load sediment transport data for nine stations at various stream discharges during water year 1999 (USGS 2000d). These data can be used to estimate the total load of sediment transport at each of these stations. These stations are listed below:

- 12413150, South Fork at Silverton, Idaho
- 12413470, South Fork near Pinehurst, Idaho
- 12413125, Canyon Creek above mouth at Wallace, Idaho
- 12413130, Ninemile Creek above mouth at Wallace, Idaho
- 12413445, Pine Creek below Amy Gulch near Pinehurst, Idaho
- 12413000, North Fork at Enaville, Idaho
- 12413500, Coeur d'Alene River at Rose Lake, Idaho
- 12413860, Coeur d'Alene River at Harrison, Idaho

3.5.2.2 USGS Seepage Study

In support of the RI/FS, the USGS conducted a seepage study of the Woodland Park area in Canyon Creek and the Smelterville Flats and Osburn Flats areas along the South Fork (USGS 2000e). The purpose of the study was to identify groundwater-gaining and groundwater-losing reaches in the system and to quantify metal discharge through these reaches. The results of the seepage study were reviewed to identify regions where groundwater enters the stream channels or surface water leaves the stream channels and enters groundwater.

3.5.2.3 Flood Insurance Studies

The Federal Insurance Administration (FIA) completed several flood insurance studies (FIS) for the various municipalities and unincorporated areas of Shoshone and Kootenai Counties in 1979 and 1984 (FIA 1979a through 1979f, and 1984). These studies provide estimated discharges and water surface profiles for floods with various recurrence intervals. A recurrence interval is the length of time between events (e.g., floods) of the same magnitude. Recurrence intervals are primarily based on measured relationships; however, comparison of these values to computed values provides an additional level of confidence of recurrence intervals computed in other manners or where recurrence intervals were not calculated.

3.5.2.4 Other Data Sets

For this RI/FS, an electronic database was used to compile thousands of individual discharge measurements reported by MFG, IDEQ, URS, EPA, and USGS from 1991 to 1999. References for each of these data sets are included in Section 4.1. These measurements provide a snapshot of hydrologic conditions at the measuring site at the time the measurement was taken.

3.5.3 Methods

3.5.3.1 Water Year 1999 Hydrograph Development

For watersheds where historical USGS monitoring station data exist, the mean daily discharge was plotted against the period of record to obtain the mean daily discharge hydrograph. An example is shown in Section 5.4. For watersheds where no data were available, mean daily discharge hydrographs were developed from available data for nearby watersheds of similar size and location. An area ratio method was used to obtain these hydrographs. Although not precise, these hydrographs predict mean daily discharge within 20 to 25 percent of the measured values for water year 1999. In some cases, this error may be within the error in monitoring station measurement. These hydrographs were reviewed to describe the surface water hydrology on a segment by segment basis. Discussions of these hydrographs are included in Parts 2 through 6 for the individual watersheds. In addition, these hydrographs were used in other sections of the RI/FS for mass loading calculations, sediment transport evaluations, and preliminary design of remediation alternatives.

3.5.3.2 Historical Hydrograph Development

The water year 1999 data set is the most complete in terms of hydrologic, sediment transport, and water quality. As such, hydrographs for water year 1999 were further examined to assess the hydrologic conditions of water year 1999 in comparison to previous years in a qualitative manner. This assessment was completed by comparing precipitation and temperature data with the mean daily discharge hydrographs and historical hydrographs, where available. An example is shown in Section 5.4. Discussions of historical water year hydrographs are included in Parts 2 through 6 for the individual watersheds.

3.5.3.3 Discharge Recurrence Interval

Log Pearson Type III analyses were completed for stations where sufficient period of record of instantaneous peak discharge was available. The USGS computer program PeakFQ was used in these analyses (USGS 1998). The discharges associated with specific recurrence intervals can be used for design purposes such as sizing specific remedial measures.

3.5.3.4 Seepage Study

The USGS seepage study results were reviewed and differences in inflow and outflow in the specific reaches were calculated to identify gaining and losing reaches. Bar graphs of the gaining and losing reaches, magnitudes, and discussions of watershed physical characteristics are included in Parts 2 through 6 for the individual watersheds.

3.5.3.5 Discharge Data Trend Analysis

Discharge data from nearly 10 years of monitoring were summarized in tables, reviewed for consistency with measured values, and trends observed in the long term and USGS water year 1999 data. These efforts provide additional insight to the hydrologic condition during each sampling event.

3.5.3.6 Sediment Transport Rates

Sediment transport rates and timing were estimated from the USGS sediment transport data. Stream discharge verses sediment concentration were plotted on log-log paper and a regression curve fit to the data to relate sediment concentration to stream discharge. This was completed for suspended and bedload components of sediment transport. An example of these plots is shown in Section 5.4. The regression relationship was applied to the stream discharge data to identify periods of increased sediment discharge throughout the year. Plots of date vs. sediment transported were produced. An example of these plots is shown in Section 5.4. Further discussions of these are included in Parts 2 through 6 for the individual watersheds.

3.5.3.7 Comparison of FIS and Calculated Recurrence Intervals

FIS recurrence intervals and calculated recurrence intervals were tabulated for easy review. In many cases, the recurrence intervals were very similar. In cases where substantial differences between compared values were observed, the larger discharge of the two should be considered for design purposes for conservatism. If the designer has rationale to use the less conservative estimate, that value would be permissible provided the designer understands that a less conservative assumption is being made.

3.6 CURRENT ECOLOGICAL CONDITION

Ecological habitat conditions are summarized by habitat type, and include a brief discussion of habitat conditions within each CSM unit where the habitat is found. Geographical areas discussed are shown on Figures 1.2-1 and 1.2-2. Habitat types present in the Coeur d'Alene Basin include riverine, lacustrine, palustrine, riparian, upland, and agricultural habitats. The discussion of habitat conditions includes human activities and their impacts on habitat quality. The information summarized here is largely from the studies associated with the NRDA injury assessment report (Stratus 2000) and literature citations presented therein, which was prepared for the natural resource trustees for the Coeur d'Alene Basin.

All habitats have been impacted, but to varying degrees, by human activities. The two largest sources of habitat impact are mining activities and timber harvesting. Within the Coeur d'Alene Basin, both of these activities started in the mid to late 1800s.

Mining-related activities included the development of roads, mines, mill sites, and a smelter. The mining and milling of ore created large volumes of waste rock and tailings that were dumped in and near streams and rivers. Much of the Basin was also systematically harvested for timber (Cross and Everest 1995). Timber harvests were conducted using railroads, splash dams, and log drives. Extensive networks of roads developed for mining exploration and timber harvesting are present in varying densities throughout the Basin. These activities have resulted in most streams within the Basin being paralleled by roads. Other human activities with lesser impact on habitats within the Coeur d'Alene Basin include agricultural practices (which include crop production and livestock grazing), and development of residential areas and commercial centers.

The cumulative effect of human activities within the Coeur d'Alene Basin has been to degrade the condition of the various habitats present. The quantity and quality of available habitats has been reduced. Habitat-forming and -maintaining processes have been destabilized (Casner 1991; Cross and Everest 1995; Hagler Bailly 1998), which, in turn, have affected stream channel stability and morphology, seasonal stream flow patterns, and cycling and transport of nutrients. Many stream sections are now channelized. Sediment and bedload transport processes within streams are unstable and there is loss of riparian vegetation. The high density of roads, along with other alterations in land use activity, has fragmented upland habitats and reduced habitat quality for native wildlife species.

Mining-related metal concentrations in surface water, soil, sediment, and biotic tissues are elevated throughout many parts of the Basin, and have been associated with increased mortality and decreased survival and growth of various plant and animal species throughout the Basin (Stratus 2000). Adverse effects of metals on survival, growth, and reproduction of ecological receptors are directly due to the toxicity of metals. Toxic effects of mining-related hazardous substances are evaluated in detail in the Final Ecological Risk Assessment (CH2M HILL and URSG 2001).

The main focus of this discussion of ecological conditions is the physical and biological characteristics of the Basin that have been indirectly affected by mining-related activities. Indirect effects of metals are the physical changes to habitats that result after one or more individual ecological receptors have been directly affected by metals. An example of an indirect effect of metals is the increase in summer water temperatures in streams, which results from the lack of shading of streams as a result of the reduction in or absence of riparian vegetation. The loss of riparian vegetation is the result of a direct toxic effect of metals in soil on the vegetation itself (Stratus 2000). The conclusions of the risk analyses of physical stressors are summarized in the ecological risk assessment (CH2M HILL and URSG 2001).

3.6.1 Riverine Habitat

In portions of the Coeur d'Alene River basin (such as the North Fork and the headwaters of several smaller streams tributary to the South Fork) upstream of mining activities, streams support fish and benthic invertebrate populations comparable to those of reference streams. Salmonid species found include cutthroat, brook, and rainbow trout. Sculpins are also abundant in streams not impacted by mining activities.

As one proceeds downstream into areas where mining activities occurred, ecological conditions and habitat quality of streams become degraded relative to conditions in mining-unimpacted stream segments. In general, the following changes are seen in riverine habitats impacted by mining activities within CSM Units 1 and 2:

- Fish species richness and fish population abundance are reduced. Sculpins are absent from the more heavily mining-impacted stream segments. The most heavily impacted areas of CSM Unit 1 are devoid of all fish.

- Benthic macroinvertebrate taxa richness and abundance decline in mining-impacted streams.

- Acute and/or chronic AWQC are commonly exceeded for cadmium, lead, and zinc in the heavily mining-impacted stream segments.

- Habitat conditions for aquatic species are poor. Stream channel structure becomes degraded, streams are channelized in some locations, and the lack of riparian vegetation to shade streams results in elevated stream temperatures during base flow periods in warm weather.

- Large inputs of fine- and coarse-grained material to the stream have altered bottom substrates within streams.

Streams in which these changes occur include portions of the South Fork, Canyon Creek, Ninemile Creek, Big Creek, Moon Creek, Pine Creek, and Prichard Creek. The magnitude of the changes varies from creek to creek and also at locations within any given stream, but the general trends are the same.

Fish population assessments conducted in the main stem confirm the presence of numerous fish species (Stratus 2000). However, the information gathered is too limited to use to draw conclusions about the current status of fish populations. Several salmonid species are known to inhabit the main stem for all or part of their life cycles, or to transit the lower river during migration. Several exotic species have been introduced and have become established in the lower Coeur d'Alene River basin as well, including rainbow trout, chinook salmon, bass, tench, northern pike, and tiger muskelunge. The introduction of non-native species has altered the trophic dynamics of the river system, with unknown effects on native fish species. Laboratory studies conducted using cutthroat trout showed that trout avoided water containing cadmium, lead, and zinc at concentrations typical of those found at Cataldo and Harrison (Woodward et al. 1997).

No recent information on the macroinvertebrate community composition of the main stem has been identified. Therefore, the current status of the macroinvertebrate community cannot be determined at this time.

Bottom conditions in the Spokane River range from cobbles in the free flowing reaches to finegrained material in the reservoirs, where reduced water velocity allows the fine-grained materials to settle out (Kleist 1987). Fine-grained sediment in the Spokane River is contaminated with cadmium, lead, and zinc, with generally decreasing concentrations from upstream to downstream.

Distinct benthic invertebrate communities are found in the different substrate types (Kleist 1987). The diversity of the invertebrate community in the Spokane River was found to be below what should be expected for a river of this size, location, and morphology (Falter and Mitchell 1982; Funk, Rabe, Filby, Parker, et al. 1973; Funk, Rabe, Filby, Bailey, et al. 1973; Gibbons et al. 1984). Kleist (1987) also reported a low diversity of benthic invertebrates, with diversity being lowest in impounded reaches of the river where midge larvae (family Chironomidae) were dominant. However, invertebrate densities appear to be sufficient to sustain a relatively large forage base (Pfeiffer 1985).

The fish community of the Spokane River is diverse and moderately productive. More than 20 species of fish have been identified in the Spokane River, many of which have been introduced to provide enhanced recreational opportunities (Bennett and Underwood 1988; Kleist 1987; Maret and Dutton 1999). Annual growth of introduced rainbow trout in the Spokane River is good, especially during their first year (Bennett and Underwood 1988). The Spokane River from Post Falls Dam to the Upriver Dam pool supports a moderately productive rainbow trout fishery, based partially on natural reproduction and partially on planted fish (Bennett and Underwood 1988; Johnson 1997). However, mortality was attributed to post-spawning adult mortality, high zinc concentrations, elevated summer temperatures, and/or low summer flows. A tournament largemouth bass fishery exists in the Long Lake Reservoir (Pfeiffer 1985). There is a high abundance of nongame fish (e.g., northern pike, minnow, suckers) in the impounded waters of the Spokane River (Pfeiffer 1985).

3.6.2 Lacustrine Habitat

The Coeur d'Alene Basin is located within the Pacific migration flyway and provides important habitat for migratory waterfowl and a diverse assemblage of aquatic and terrestrial species (Stratus 2000). The lateral lakes area contains abundant and diverse lacustrine, palustrine, and riparian habitats that support multiple wildlife uses including feeding, resting, and reproduction. There is a great deal of overlap of the lacustrine, palustrine, and riparian habitat within the main stem Coeur d'Alene River (CSM Unit 3), so the following discussion of current ecological conditions in lacustrine areas applies equally as well to many palustrine and riparian habitats throughout the Basin.

More than 280 bird species are known or suspected to occur in the lateral lakes area. Wildlife resources in the Coeur d'Alene River basin have been negatively affected by exposure to hazardous substances released from mining and mineral-processing facilities (Stratus 2000).

Lead was identified as the primary contaminant affecting wildlife in lacustrine areas of CSM Unit 3. Wildlife exposure to lead has been confirmed by the extremely high concentrations of lead in sediments (e.g., 500 to 20,000 ppm), high rates of sediment ingestion by wildlife, and documented bioaccumulation of lead in the blood and tissues of multiple species of wildlife. Multiple adverse effects caused by lead have been observed in wildlife within the vicinity of the lateral lakes. Biological responses observed in wildlife include death of large numbers and species, physiological malfunctions, and physical deformities. For example, between 1992 and 1997, 289 tundra swans were found dead or sick in the Coeur d'Alene River basin versus 8 dead or sick tundra swans in a comparable reference location on the St. Joe River (Stratus 2000).

The lateral lakes contain a mixture of coldwater and warmwater fish species, with warmwater species dominating. Laboratory studies conducted using cutthroat trout showed that trout avoided water containing cadmium, lead, and zinc at concentrations typical of those found at Cataldo and Harrison (Woodward et al. 1997). In a subsequent study, zinc was found to be primarily responsible for the avoidance response.

The water quality of Coeur d'Alene Lake has been impacted by sediments, heavy metals, and other pollutants (R2 Resources undated). The metals contaminants are the result of extensive mining operations in the basin, while ongoing timber harvest activities and developed and agricultural areas have introduced nutrients and oxygen-demanding substances (Woods and Beckwith 1997).

Coeur d'Alene Lake contains a diverse mix of coldwater and warmwater fish species, many of which are introduced non-natives (Stratus 2000). Coeur d'Alene Lake is heavily used for recreational boating and fishing and is a major regional attraction as a recreation and tourist area (Woods and Beckwith 1997). Kokanee salmon were introduced to the lake in 1937 and the population is self-sustaining and productive (IDFG 1980). The native fish community in Coeur d'Alene Lake includes westslope cutthroat trout, bull trout, mountain whitefish, northern squawfish, suckers, and various species of sculpins (R2 Resources undated).

Studies of the macroinvertebrate communities of Coeur d'Alene Lake were conducted in 1971 (Winner 1972) and 1995 (Ruud 1996). Winner (1972) observed strong dominance of chironomids and oligochaetes in benthic macroinvertebrate communities of Coeur d'Alene Lake. He did not find a relationship between sediment zinc concentrations and the distribution of chironomids and oligochaetes. Ruud (1996) found that the macroinvertebrate communities in Coeur d'Alene Lake varied with depth and location. The south end of the lake has the highest biological productivity. The macroinvertebrate communities in Coeur d'Alene Lake differed substantially from those found in Priest Lake, considered a comparable reference area. Total abundance, total biomass, taxa richness, and mean diversity were positively correlated with zinc concentration in water. However, Ruud provided no quantitative estimates of the effects of metals on the benthic community of Coeur d'Alene Lake, and has a potentially high "false positive" error rate among Ruud's 306 correlation analyses.

Concentrations of a variety of inorganic substances in the sediments of Coeur d'Alene Lake are enriched in approximately 85 percent of the lakebed surface (Woods and Beckwith 1997). The metal-contaminated sediments tend to be very fine-grained (less than 63 μm), and are readily mobilized by currents within the lake. The thickness of the contaminated sediments ranges from 17 to more than 119 cm, with the thickest deposits generally near the mouth of the Coeur d'Alene River (Horowitz et al. 1993). Concentrations of hazardous substances occur above sediment quality guidelines that are indicative of severe pollution, with the potential to significantly impact benthic organisms.

Concentrations of metals in waters of Coeur d'Alene Lake have the potential to affect aquatic organisms. Concentrations of zinc measured in Coeur d'Alene Lake water frequently exceed acute AWQC (Stratus 2000). Laboratory toxicity tests with water containing metal concentrations found in Coeur d'Alene Lake have observed that zinc levels strongly inhibit growth of three phytoplankton isolates from the lake (Woods and Beckwith 1997). Cutthroat trout evidenced significant avoidance of test waters containing mixtures of hazardous substances representing the metals concentrations in Coeur d'Alene Lake (Woodward et al. 1997; Stratus 2000). Zinc was found to be primarily responsible for the avoidance.

3.6.3 Palustrine Habitat

Palustrine areas of the main stem and associated lateral lakes have been impacted by transport and deposition of tailings from upgradient mining areas. The active bed of the Coeur d'Alene River contains approximately 9 million cubic yards of mining-waste-contaminated alluvium as sand and silt. Concentrations of cadmium, lead, and zinc in sediments from the palustrine habitats of the lateral lakes routinely exceed the ecological thresholds for the protection of benthic invertebrate communities (Stratus 2000).

As was the case for the lateral lakes area of the main stem, multiple adverse effects caused by lead and other metals have been observed in fish and wildlife in the palustrine portions of the lateral lakes. Adverse effects have been observed on survival, reproduction, growth, and behavior. The appearance of plant cover and species do not suggest that the palustrine vegetation has been obviously degraded. However, chemical analyses of palustrine vegetation (*Equisetum*, water potato) indicates that lead levels in palustrine vegetation are sufficiently elevated to serve as a direct pathway of lead to wildlife that consumes palustrine vegetation (Audet 1997; Campbell et al. 1999).

Few data are available to assess the ecological condition of the palustrine habitat in Coeur d'Alene Lake. However, the fact that the metals are present mainly in dissolved or fine particulate form has prevented accumulation of metals in sediments near shore or in shallow areas. Wave action and fluctuating lake levels winnow away from shallow water the fine sediments with which the metals are associated. An exception to this situation occurs at Harrison, where deposition of either larger amounts of particles or larger particles has resulted in elevated metals concentrations in beach sediments.

3.6.4 Riparian Habitat

Areas of the South Fork and its tributary streams that have not been impacted by mining activities have a thick riparian vegetation structure of deciduous trees and shrubs (IDEQ 1999). Non-impacted riparian zones also support a variety of bird and wildlife species.

There has been extensive modification of the riparian zone and floodplain in conjunction with historical mining-related impacts; development of residential, industrial, and transportation infrastructure; recovery of mine tailings; and ongoing remediation activities. In general, the condition of riparian habitat, in-stream habitat structure, and the stability of the channel substrate decrease from the headwaters of streams downstream to the confluence of the North and South Forks.

The riparian vegetation in the mining-impacted portions of CSM Units 1 and 2 has been significantly degraded. Little or no riparian vegetation is present throughout much of the area because of the impacts of mining-related hazardous substances, and the removal of much of the surface soil during recovery of tailings deposits for reprocessing. Given the degraded state of the riparian habitat, riparian-dependent wildlife species will be limited or absent in these areas.

Plant cover and species richness were measured in 39 sampling sites in the lateral lakes area and results suggest that the riparian vegetation has not been obviously degraded. Results of laboratory plant bioassays using soil collected from the field and four species of plants are reported in Stratus (1999). The report groups the bioassay data into two broad categories: data from assessment area sampling sites and data from reference area sampling sites. Therefore, it was not possible to assess results of the bioassays specifically for CSM Unit 3, the main stem, and the lateral lakes. However, results of the assessment versus reference area comparisons showed that plant growth performance was significantly reduced in assessment soils relative to reference soils. Correlation analyses indicted that the majority of plant growth endpoints were significantly negatively correlated with increasing concentrations of soil metals (i.e., as soil metal concentrations increase, plant growth decreases).

3.6.5 Upland Habitat

Upland habitats within the Bunker Hill Superfund site have been denuded by airborne emissions from mining facilities that contain elevated metals concentrations and acidic sulfur dioxide. Recovery has been impeded by erosion of surface soils. Upland habitats within CSM Units 1 and 2 have been modified by mine exploration/development and timber harvesting. Road densities are above thresholds believed to be limiting to upland wildlife species.

3.6.6 Agricultural Habitat

Approximately 9,500 acres of agricultural land fall within the floodplain of the main stem of the Coeur d'Alene River in CSM Unit 3. Pasture and cultivated hay fields are the dominant agricultural land uses. The agricultural habitat is by definition highly modified by grazing and other agricultural practices. However, mining-related hazardous substances have affected this habitat. The surface soils on many of the low stream terraces along the Coeur d'Alene River that are used for agriculture are termed slickens and are composed of mine tailings that have been deposited with the annual alluvium (Frutchey 1994; Soil Conservation Service 1981). Many of the soils within agricultural areas contain elevated metal concentrations. Private landowners have experimented with soil amendments to improve the agricultural productivity of tailings-contaminated soils in the Lower Coeur d'Alene to decrease leachability of metals (Frutchey 1994).

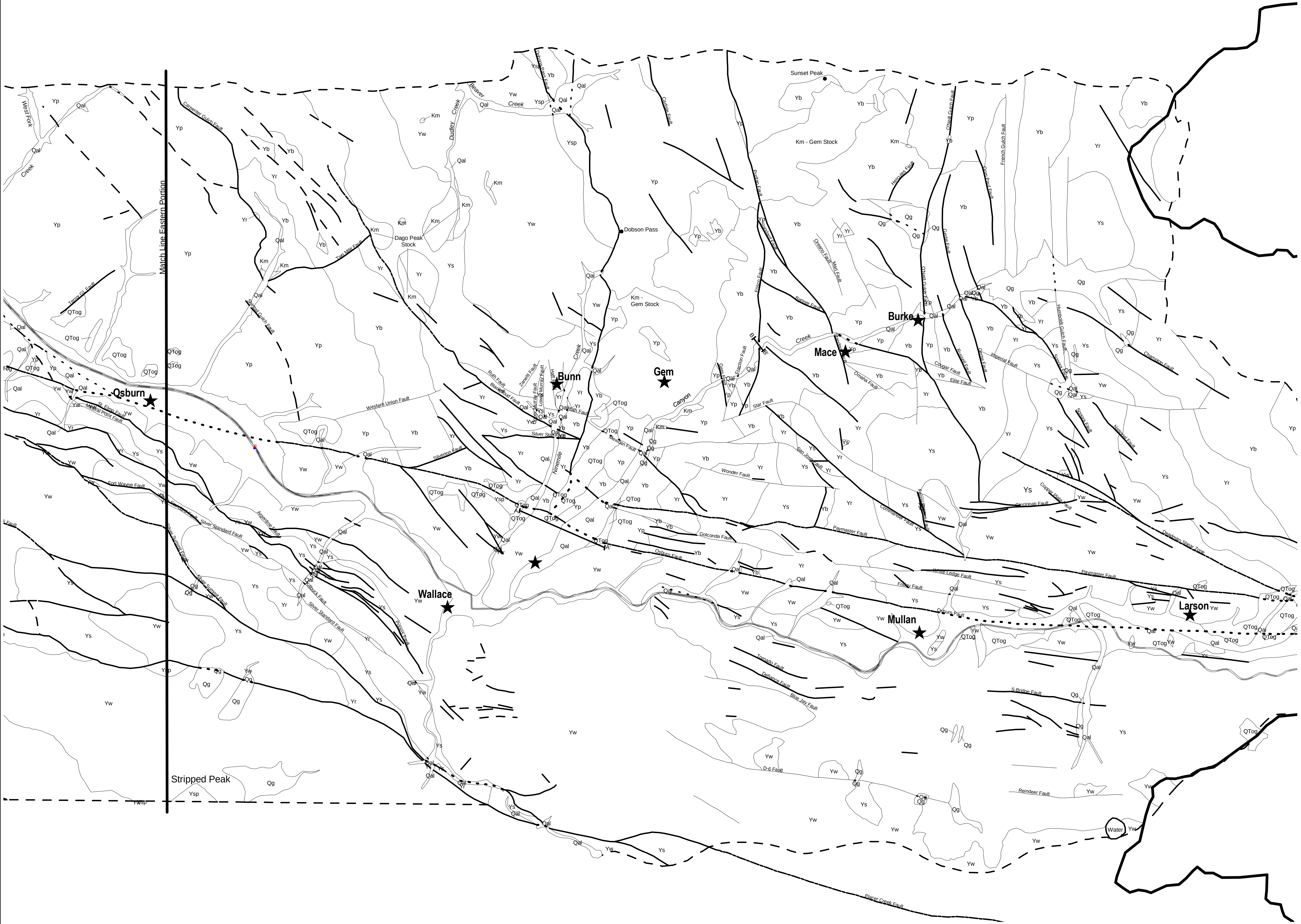

Figure 3.2-1
Geologic Map of Coeur d'Alene District, Western Portion

LEGEND

Qal	Alluvium
Qg	Glacial and Glaciofluvial Deposits
QTog	Channel and Terrace Gravels
Km	Monzonite and Associated Rocks
Yws	Wishards Sill
Ysp	Striped Peak Formation of Missoula Group, Belt Supergroup
Yw	Wallace Formation, Belt Supergroup
Ys	St. Regis Formation of Ravalli Group, Belt Supergroup
Yr	Revett Formation of Ravalli Group, Belt Supergroup
Yb	Burke Formation of Ravalli Group, Belt Supergroup
Yrb	Revett and Burke Formations (Undifferentiated) of Ravalli Group, Belt Supergroup
Yp	Prichard Formation, Belt Supergroup

- Geologic Contact
- Fault (dashed where approximated; dotted where inferred; hatches show normal downthrown block)
- Thrust Fault (dashed where approximated; dotted where inferred; thrust teeth are on upper plate)
- Interstate 90
- Town
- County/State Boundary

NOTES

1) **Geologic map obtained from USGS Open-File Report 96-299, Plate 1-1 (Derkey, Johnson, and Carver 1996).**

2) **Original digital coverage converted to NAD 83 (feet) Idaho West.**

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Coeur d' Alene Basin RI/FS
RI REPORT

EPA REGION 10

Document Control 4162500.6615.05.a
Generation 1
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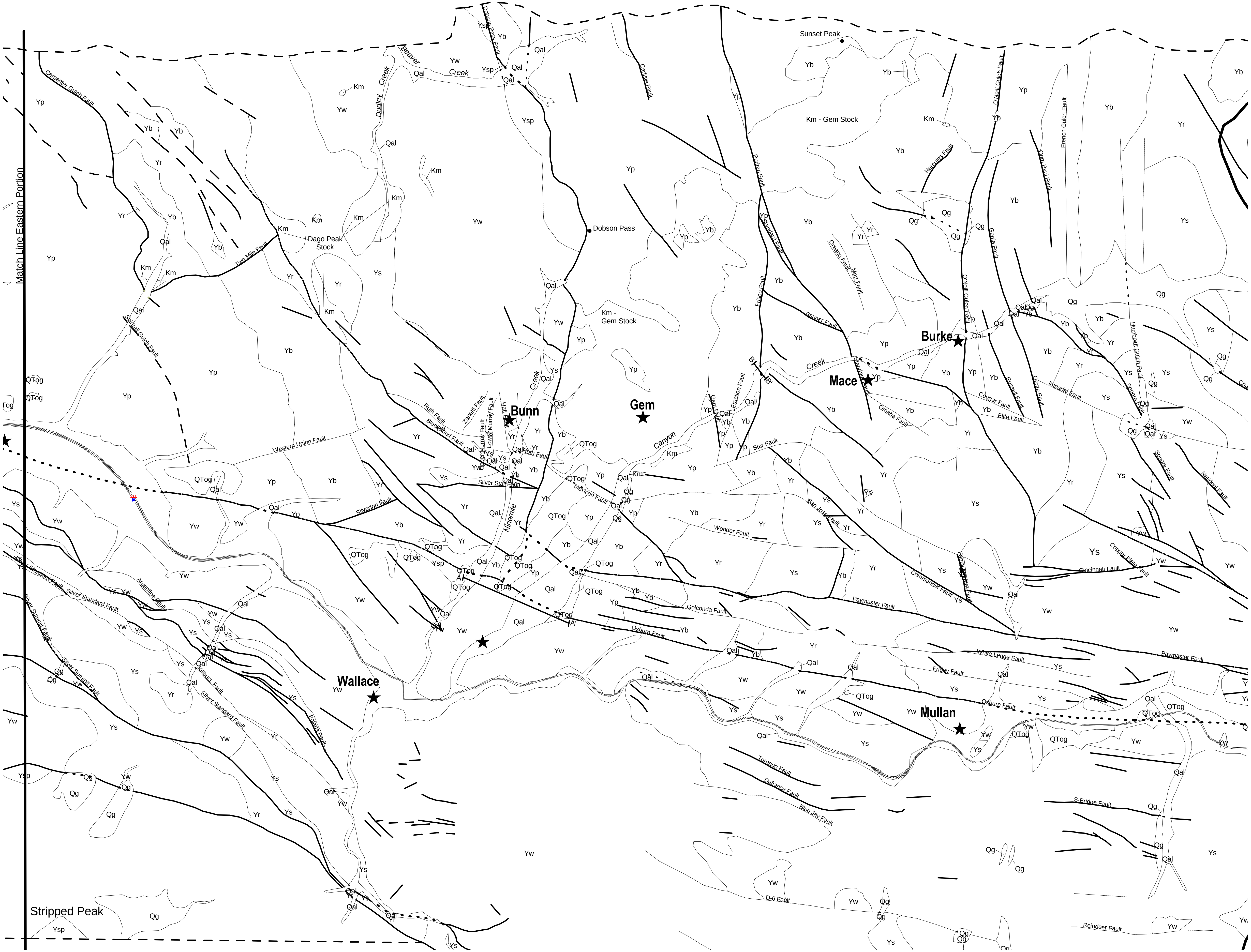
7/18/2001

This map is based on Idaho State Plane Coordinates West Zone, North American Datum 1983.

Date of Plot: July 18, 2001



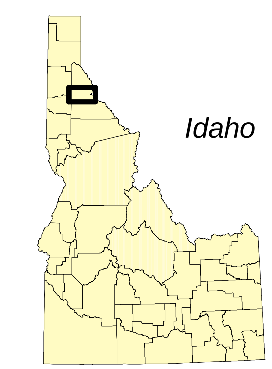


Figure 3.2-2
Geologic Map of Coeur d'Alene District, Eastern Portion

LEGEND

Qal	Alluvium
Qg	Glacial and Glaciofluvial deposits
QTog	Channel and Terrace Gravels
Km	Monzonite and Associated Rocks
Yws	Wishards Sill
Ysp	Striped Peak Formation of Missoula Group, Belt Supergroup
Yw	Wallace Formation, Belt Supergroup
Ys	St. Regis Formation of Ravalli Group, Belt Supergroup
Yr	Revett Formation of Ravalli Group, Belt Supergroup
Yb	Burke Formation of Ravalli Group, Belt Supergroup
Yrb	Revett and Burke Formations (Undifferentiated) of Ravalli Group, Belt Supergroup
Yp	Prichard Formation, Belt Supergroup

- Geologic Contact
- Fault (dashed where approximated; dotted where inferred; hatches show normal downthrown block)
- Thrust Fault (dashed where approximated; dotted where inferred; thrust teeth are on upper plate)
- Interstate 90
- Town
- County/State Boundary
- B—B' Location of Geologic Cross Section

NOTES

1) Geologic map obtained from USGS Open-File Report 96-299, Plate 1-1 (Derkey, Johnson, and Carver 1996).

2) Original digital coverage converted to NAD 83 (feet) Idaho West.

2000 0 2000 Feet

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Coeur d' Alene Basin RI/FS
RI REPORT

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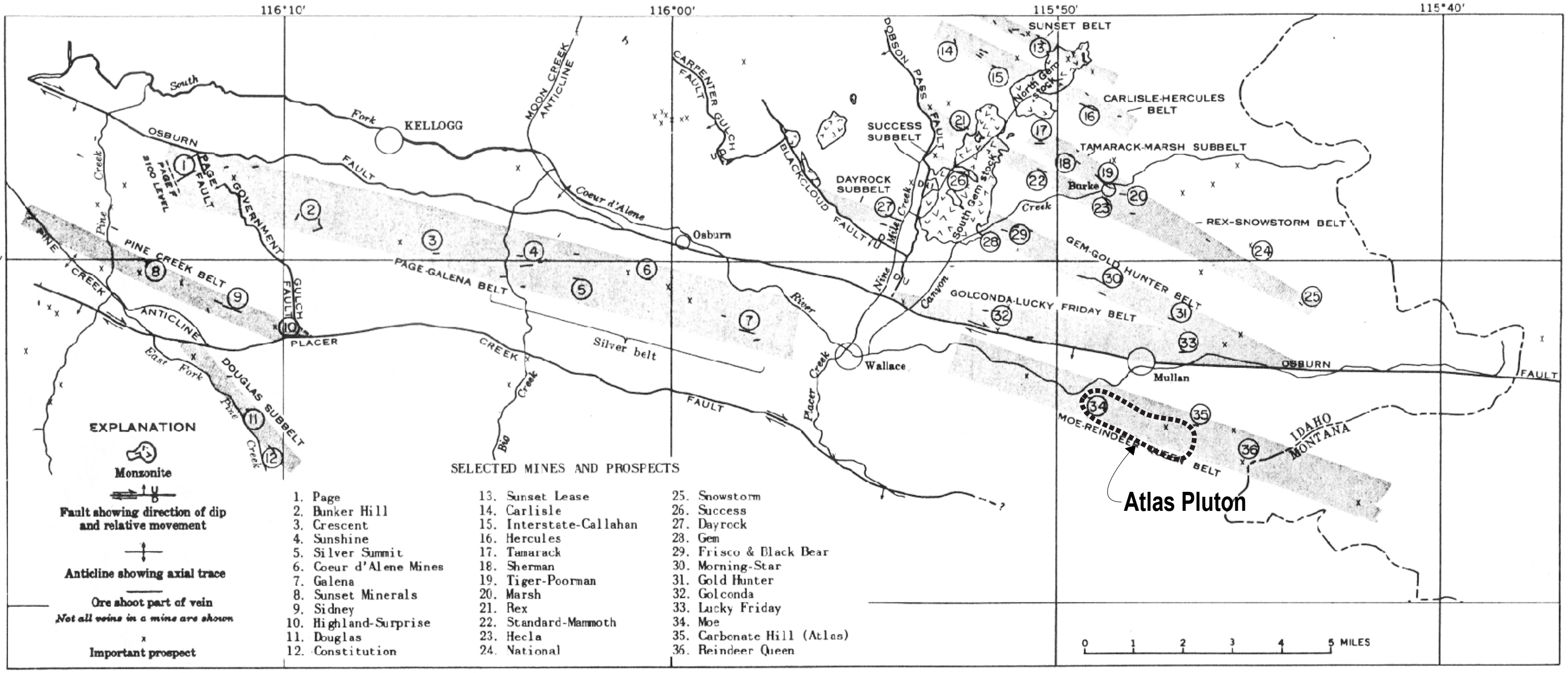
08/05/2001

This map is based on Idaho State Plane Coordinates West Zone, North American Datum 1983.

Date of Plot: August 5, 2001



Source: Modified and reprinted with permission of the American Institute of Mining, Metallurgical, and Petroleum Engineers, Inc., from Hobbs, S. Warren and Verne C. Frykland, Jr. 1968. "The Coeur d'Alene District, Idaho" Chapter 66. In Ore Deposits of the United States, 1933/1967. Vol. 2, Figure 2, p.1421. © 1968 by The American Institute of Mining, Metallurgical, and Petroleum Engineers, Inc., New York.

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Figure 3.2-3
Mineral Belts of Coeur d'Alene District

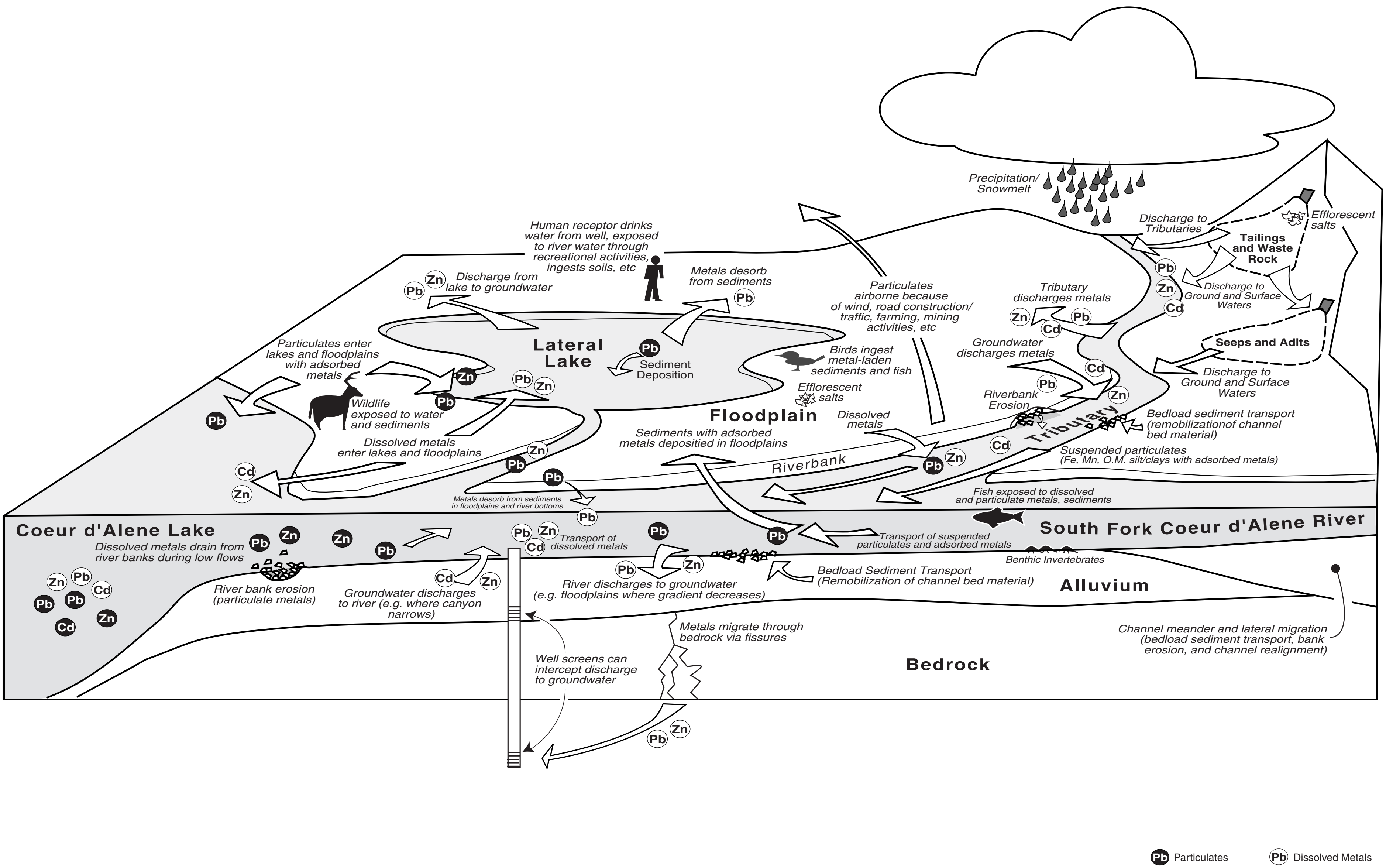

Figure 3.3-1
Conceptual Model of Fate and Transport South Fork Coeur d'Alene River and Watershed

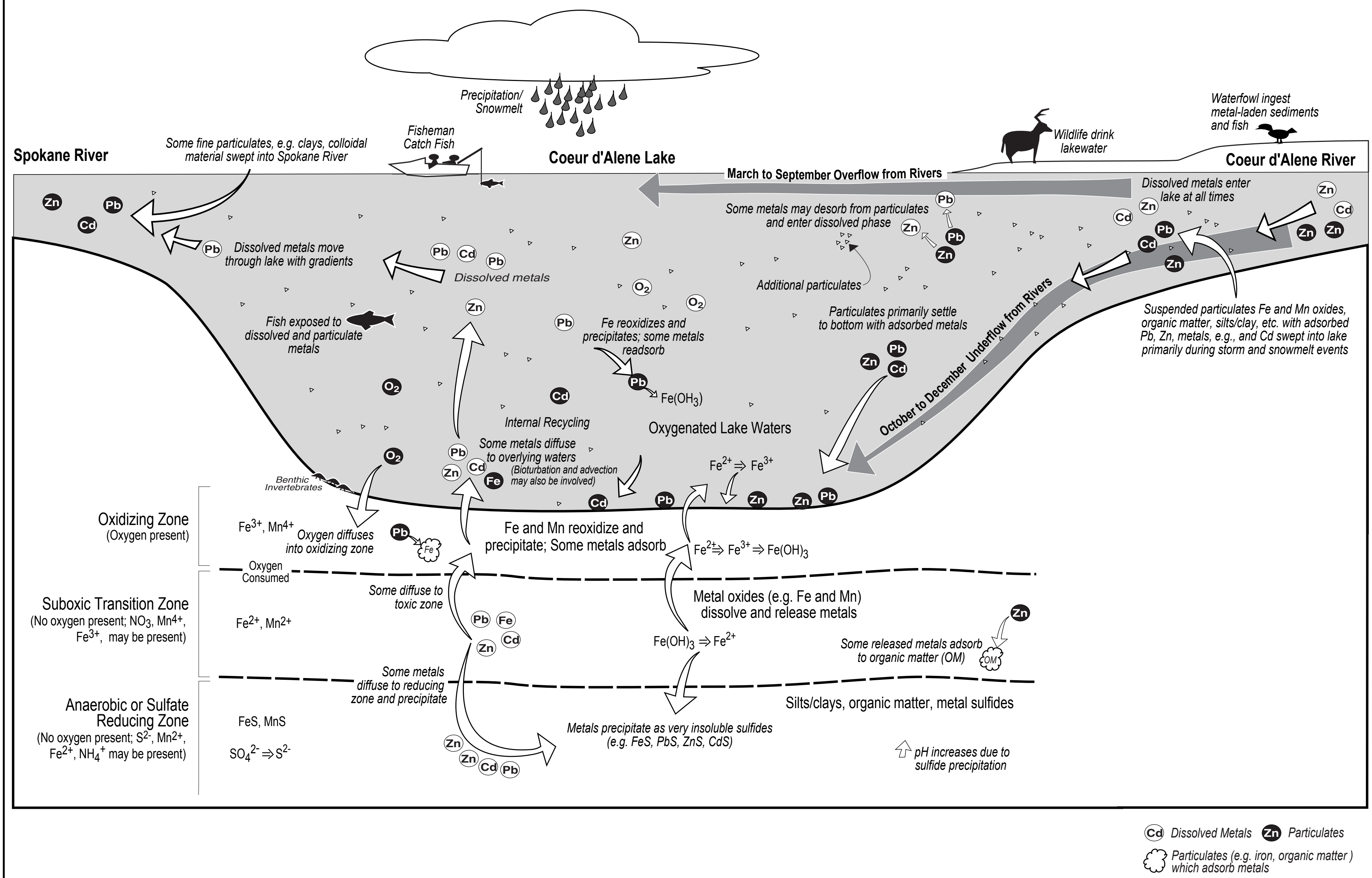

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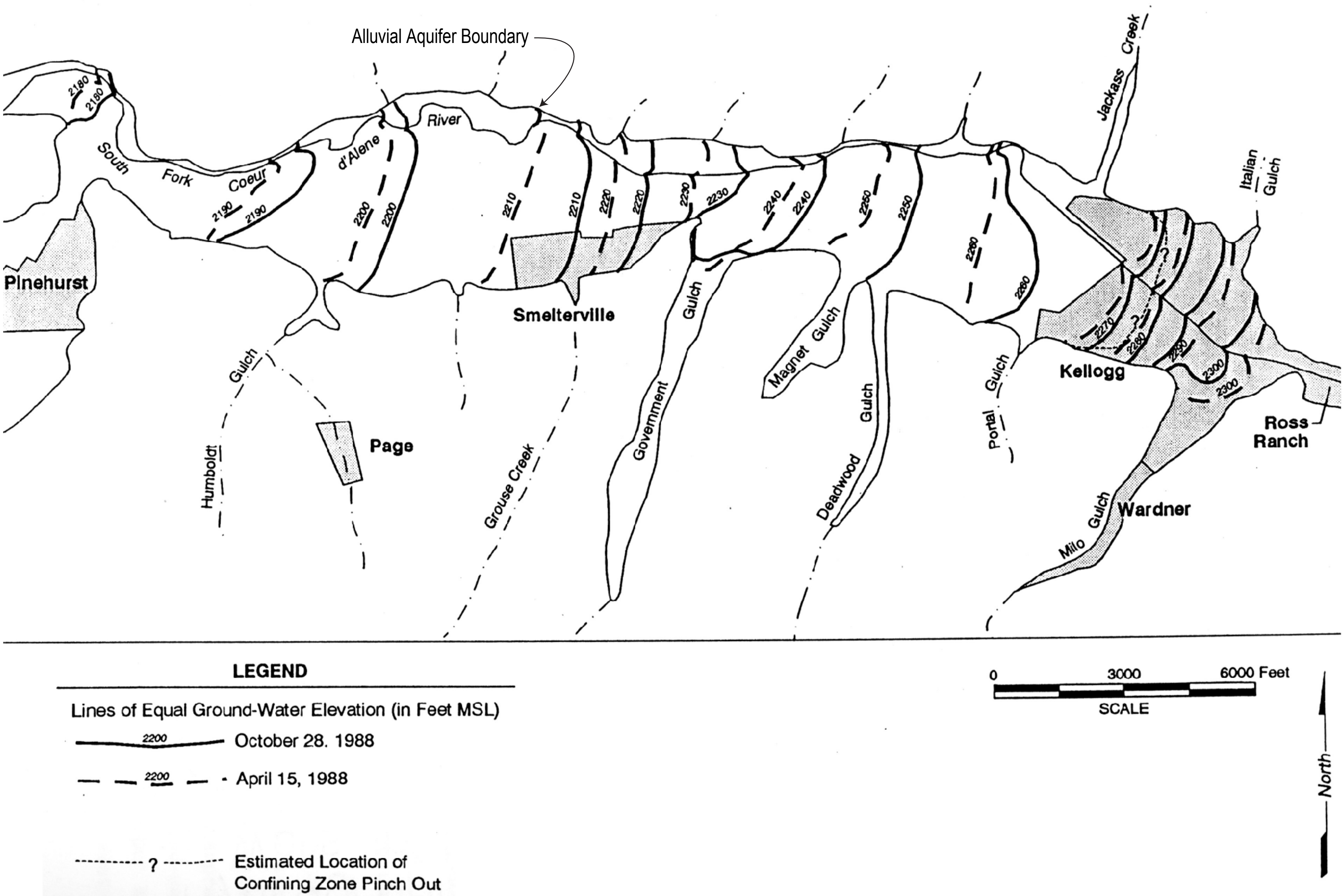
Figure 3.3-2
Conceptual Model of Fate and Transport in Coeur d'Alene Lake and Lateral lakes



Source: Dames & Moore, 1991. Bunker Hill RI/FS, Task 3.0, Revised Final Hydrogeologic Assessment, Volume I - text.

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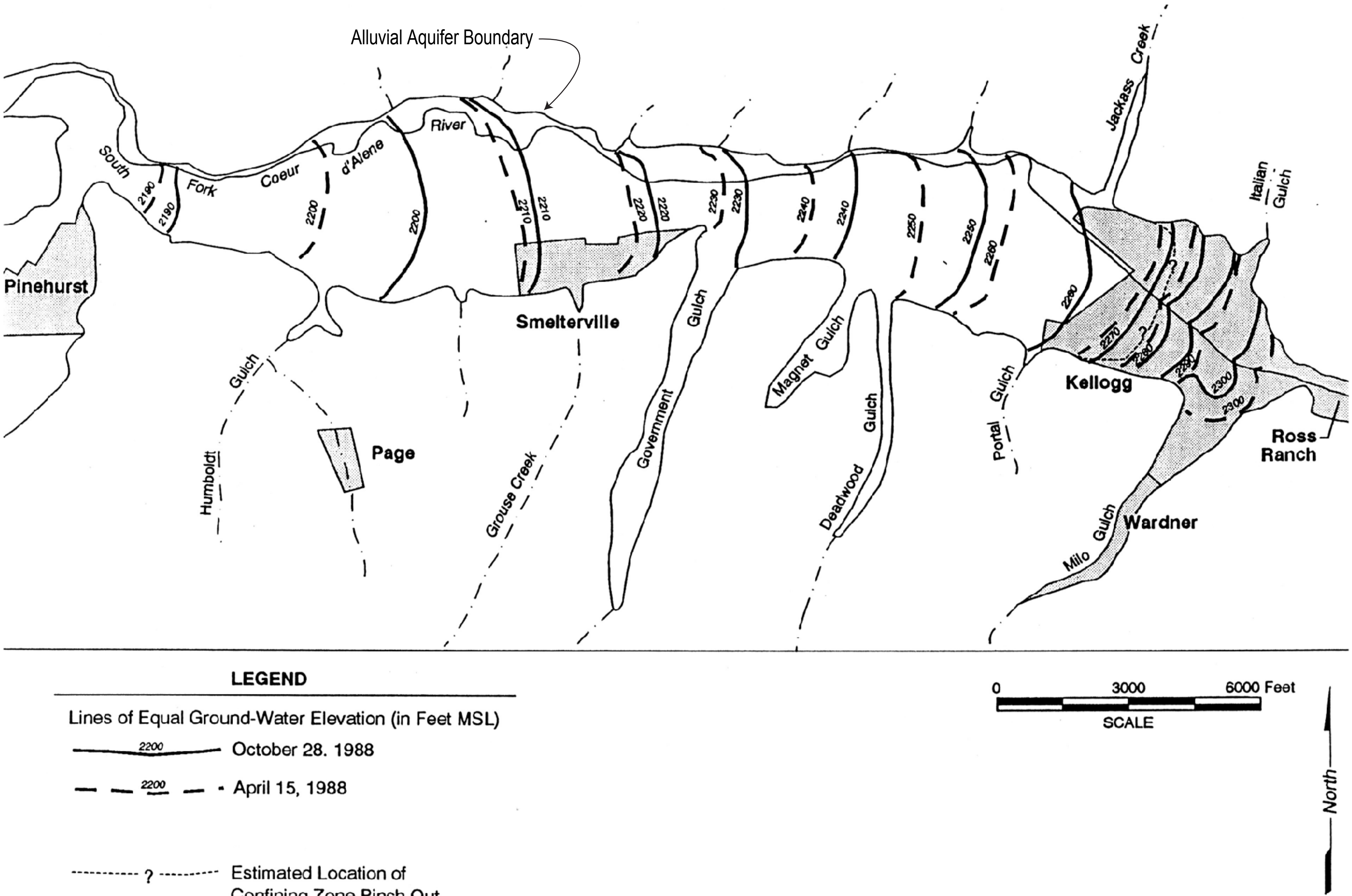
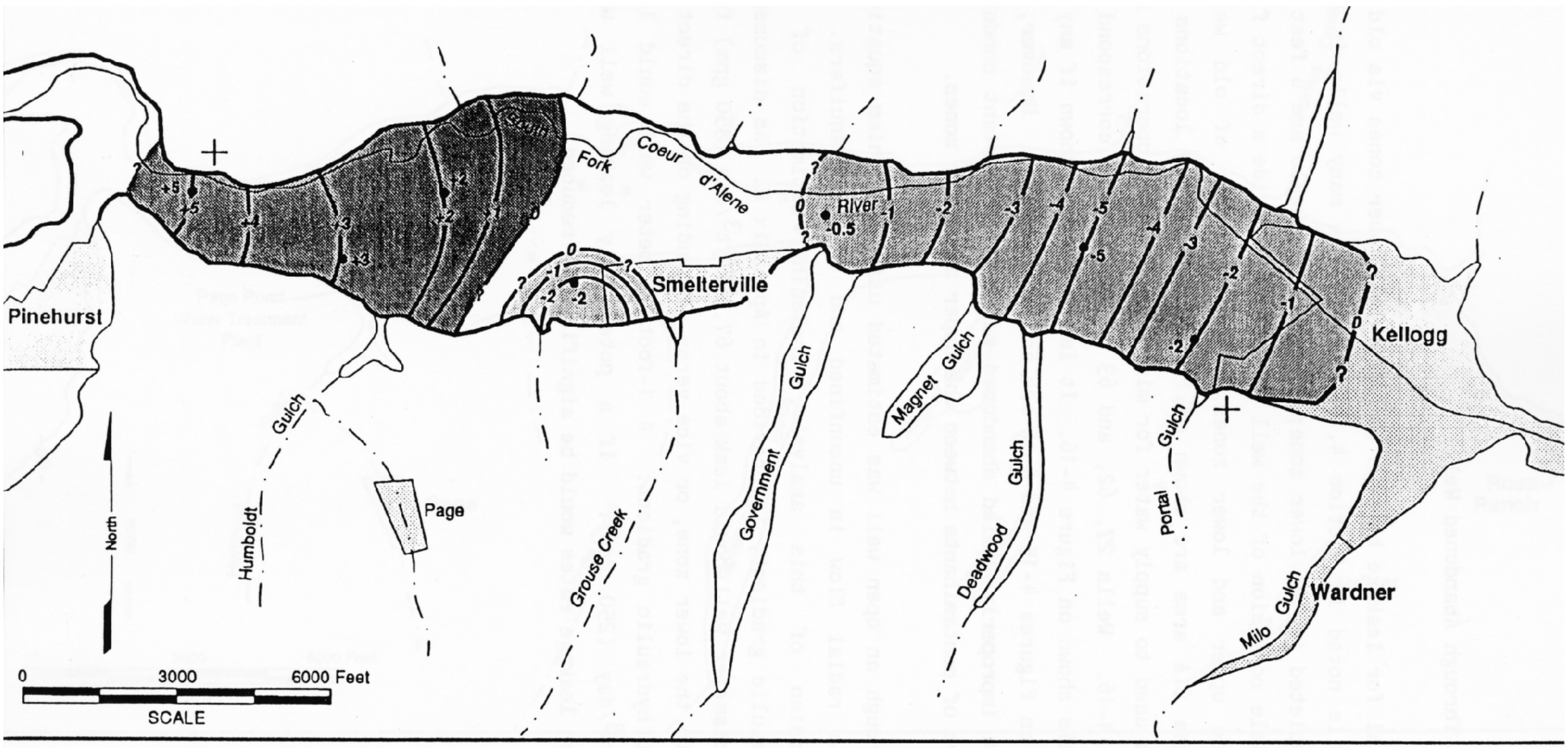
Figure 3.4-1
Groundwater Elevation Contour Map for the Upper Zone of the Valley Aquifer System
April 15, 1988 - October 28, 1988



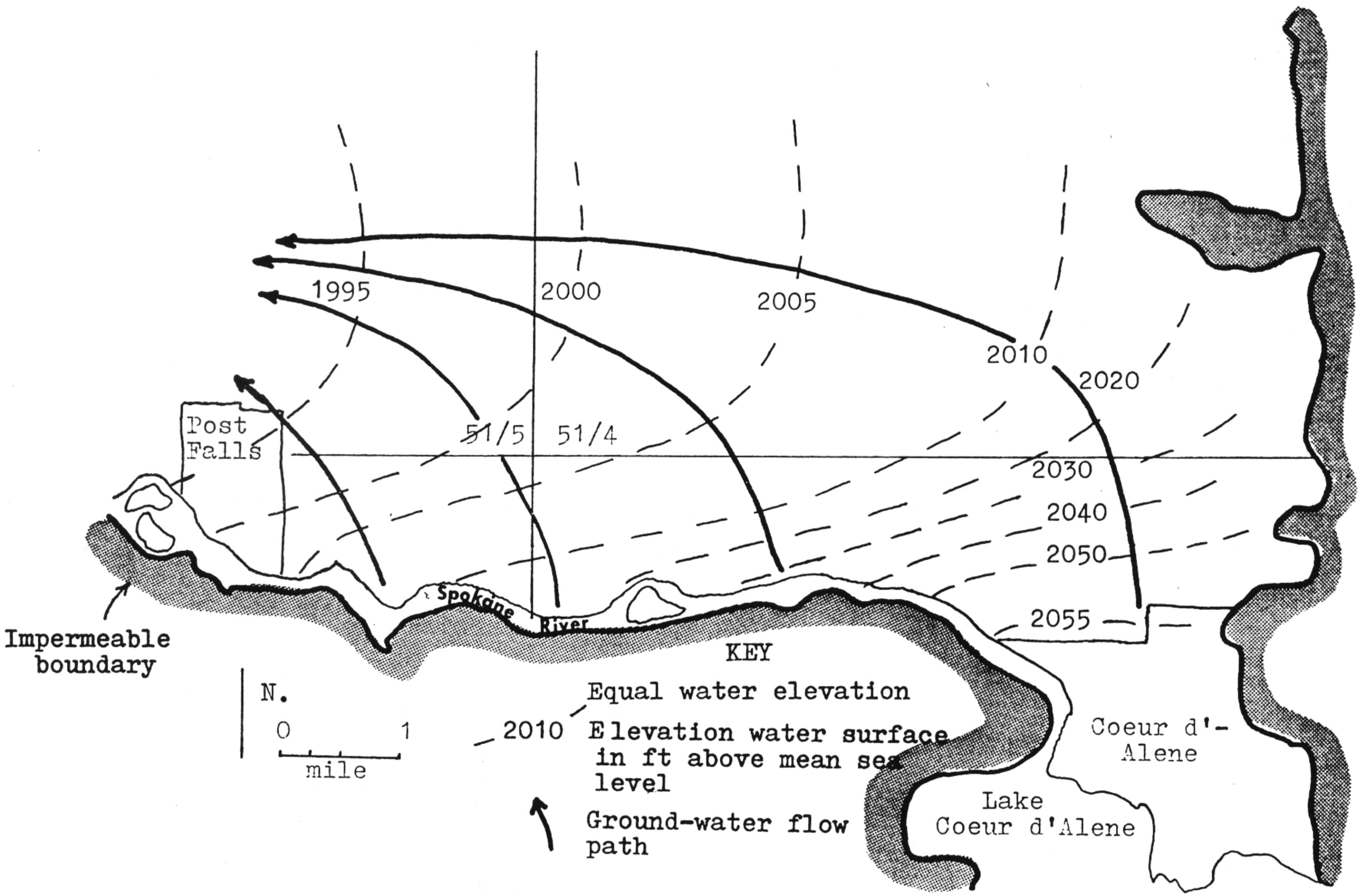
Source: Dames & Moore, 1991. Bunker Hill RI/FS, Task 3.0, Revised Final Hydrogeologic Assessment, Volume I - text.

EPA REGION 10	027-RI-CO-102Q Coeur d'Alene Basin RI/FS RI REPORT	Doc. Control: 4162500.6615.05.a Generation: 1 RI-345 051700	**Figure 3.4-2** **Groundwater Elevation Contour Map for the Lower Zone of the Valley Aquifer System** **April 15, 1988 - October 28, 1988**



Source: Dames & Moore, 1991. Bunker Hill RI/FS, Task 3.0, Revised Final Hydrogeologic Assessment, Volume I - text.

Figure 3.4-3
Head Differential Across Confining Zone Areas of Downward and Upward Gradient
April 15, 1988 - October 28, 1988



Source: Sagstad, 1976

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Figure 3.4-4
Contours of Water Level Elevation, Eastern Rathdrum Prairie Study Area

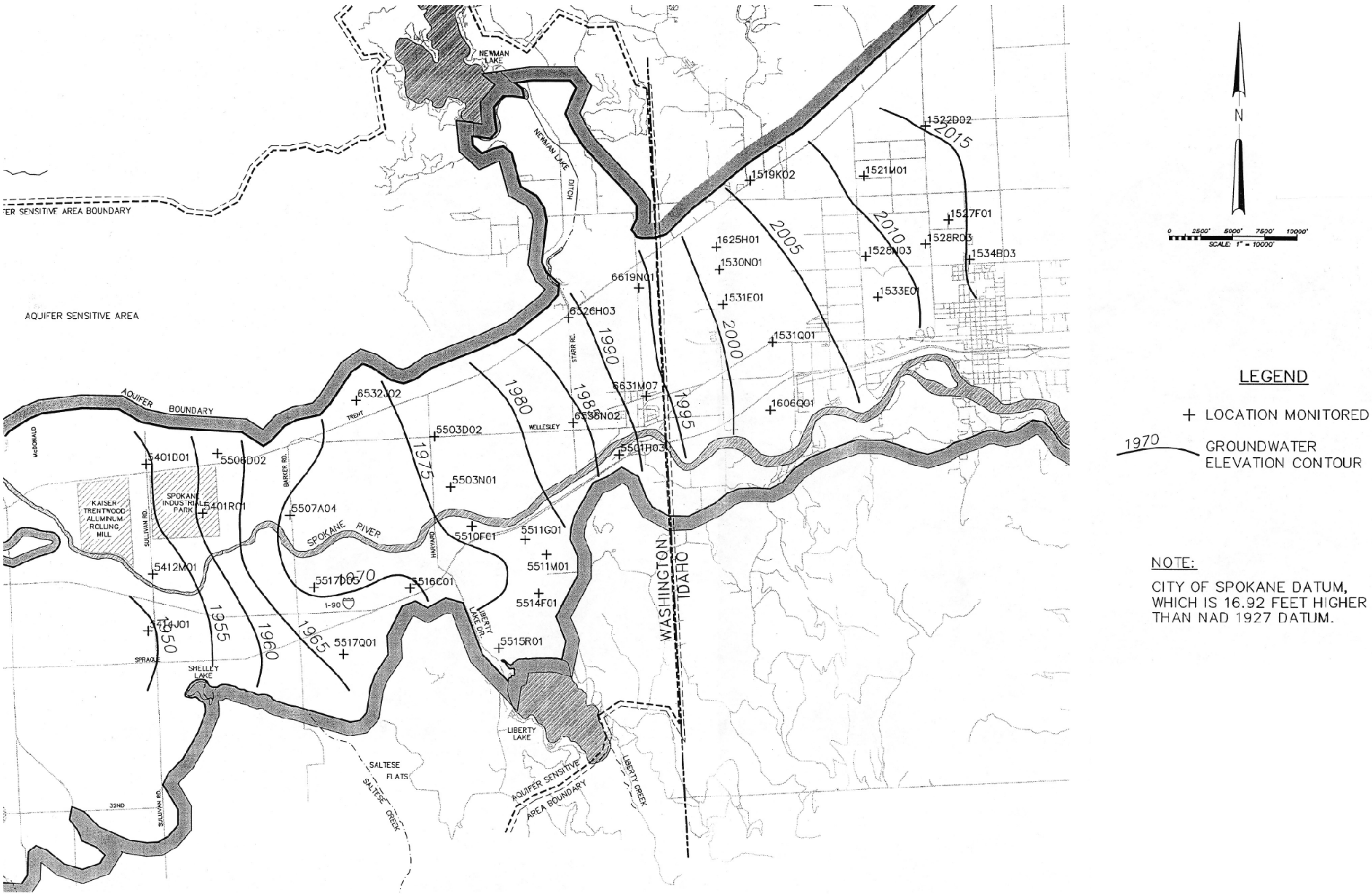

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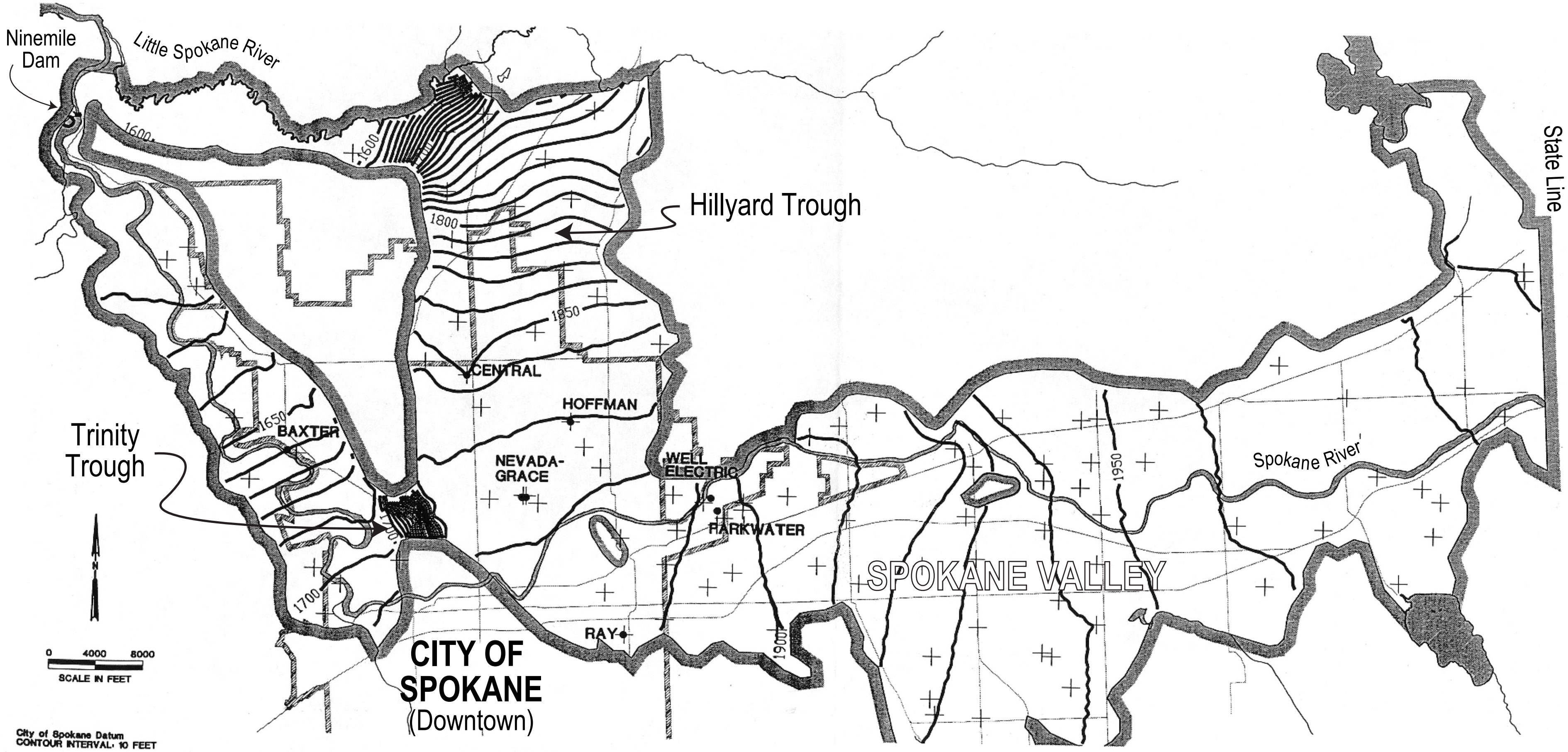
Figure 3.4-5
Contours of Water Level Elevation, Central Rathdrum Prairie Study



Groundwater level contours based on City of Spokane vertical datum - 16.92' Higher than NAD 1927 datum

EPA REGION 10	027-RI-CO-102Q Coeur d'Alene Basin RI/FS RI REPORT	Doc. Control: 4162500.6615.05.a Generation: 1 RI-343 062300	**Figure 3.4-6** **Contours of Water Level Elevation, Western Rathdrum Prairie Study**

Table 3.2-1
Characteristics of Belt Supergroup in Coeur d'Alene District

Group	Formation		Lithology	Thickness (feet)	Ore-Bearing
Missoula	Striped Peak Formation		Interbedded quartzite and argillite with some arenaceous dolomitic beds. Purplish gray and pink to greenish gray. Ripple marks and mud cracks common. Top eroded.	1,500+	No
	Wallace Formation	Upper part	Mostly medium- to greenish-gray finely laminated argillite. Some arenaceous dolomite and impure quartzite, and minor gray dolomite and limestone in the middle part.	4,500 - 6,500	Yes, but limited
		Lower part	Light-gray more or less dolomitic quartzite interbedded with greenish-gray argillite. Ripple marks and mud cracks abundant.		
Ravalli	St. Regis Formation	Upper part	Light greenish-yellow to light green-gray argillite; thinly laminated. Some carbonate-bearing beds.	1,400 - 2,000	Yes
		Lower part	Gradational from thick-bedded pure quartzite at base to interbedded argillite and impure quartzite at top. Red-purple color characteristic; some green-gray argillite. Some carbonate-bearing beds. Ripple marks, mud cracks, and mud-chip breccia common.		
	Revett Formation		Thick-bedded vitreous light yellowish-gray to nearly white pure quartzite. Grades into nearly pure and impure quartzite at bottom and top. Cross-stratification common.	1,200 - 3,400	Yes
	Burke Formation		Light greenish-gray impure quartzite. Some pale red and light yellowish-gray pure to nearly pure quartzite. Ripple marks, swash marks, and pseudoconglomerate.	2,200 - 3,000	Yes
	Prichard Formation	Upper part	Interbedded medium-gray argillite and quartzose argillite and light-gray impure to pure quartzite. Some mud cracks and ripple marks.	12,000 +	Yes
		Lower part	Thin- to thick-bedded, medium gray argillite and quartzose argillite; laminated in part. Pyrite abundant. Some discontinuous quartzite zones. Base buried.		

Source: Hobbs et al. 1965

Table 3.2-2
90th Percentile Distribution of Elements in Bedrock
in the Monzonite Stocks and the Wallace, St. Regis, and Revett Formations, Coeur d'Alene District

Element	Monzonite (106 samples)		Wallace (998 samples)		St. Regis (839 samples)		Revett (455 samples)		All Formations[a] (3,979 samples)	
	# of Valid Observations	90th Percentile	# of Valid Observations	90th Percentile	# of Valid Observations	90th Percentile	# of Valid Observations	90th Percentile	# of Valid Observations	90th Percentile
Antimony[b]	106	1.1	992	7.4	830	9.5	452	10	3,965	7.9
Arsenic[b]	—	—	993	27	832	18	455	20	3,969	24
Barium	106	1,661	993	1,088	839	1,780	455	1,030	3,979	1,085
Beryllium	106	2.4	993	2.4	839	2.5	455	1.8	3,979	2.4
Boron	106	—	993	221	839	236	455	131	3,979	166
Cadmium[c]	106	0.96	987	1.3	834	0.9	453	0.7	3,959	1.1
Calcium[d]	106	1.8	993	2.2	839	0.17	455	—	3,979	0.86
Chromium	106	25	993	55.8	839	50	455	31	3,979	60
Cobalt	106	13	993	15.9	839	15	455	8.8	3,979	15
Copper[c]	105	69	980	76	834	70	449	45	3,950	69
Iron[d]	106	5.4	993	6.8	839	7.1	455	5.5	3,979	6.9
Lanthanum	106	92	993	54	839	53	455	55	3,979	56
Lead[c]	106	51	993	188	839	111	455	301	3,979	140
Magnesium[d]	106	0.54	993	2.2	839	1	455	0.25	3,979	1.2
Manganese	106	1,130	993	1,883	839	4,760	455	4,723	3,979	2,508
Mercury[e]	106	0.1	988	0.19	828	0.16	453	0.15	3,922	0.14
Molybdenum	106	—	993	—	839	—	455	—	3,979	—
Nickel	106	9.6	993	29	839	25	455	15	3,979	25
Scandium	106	9.8	993	14	839	12	455	10	3,979	14
Silver[c]	106	0.9	990	1.1	831	1	452	0.9	3,961	1

Table 3.2-2 (Continued)
90th Percentile Distribution of Elements in Bedrock
in the Monzonite Stocks and the Wallace, St. Regis, and Revett Formations, Coeur d'Alene District

Element	Monzonite (106 samples)		Wallace (998 samples)		St. Regis (839 samples)		Revett (455 samples)		All Formations[a] (3,979 samples)	
	# of Valid Observations	90th Percentile	# of Valid Observations	90th Percentile	# of Valid Observations	90th Percentile	# of Valid Observations	90th Percentile	# of Valid Observations	90th Percentile
Strontium	106	1,873	993	—	839	—	455	—	3,979	—
Sulfur[d,f]	12	0.01	971	0.03	795	0.025	423	0.01	3,735	0.04
Titanium[d]	106	0.39	993	0.44	839	0.4	455	0.36	3,979	0.4
Vanadium	106	207	993	97	839	75	455	50	3,970	97
Yttrium	106	32	993	51	839	45	455	36	3,979	48
Zinc[c]	106	108	933	209	832	90	452	70	3,963	130
Zirconium	106	183	993	379	839	477	455	1,095	3,979	489

[a]Includes monzonite stocks and all formations in Tables 3.2-2 and 3.2-3
[b]Colorimetric analysis
[c]Atomic absorption analysis
[d]In percent
[e]Mercury vapor detector analysis
[f]Leco combustion analysis

Notes:
Values are in parts per million except as indicated. Analyses are spectrographic unless otherwise indicated.
Dash indicates no data available.

Source: Gott and Cathrall 1980

Table 3.2-3
90th Percentile Distribution of Elements in Bedrock
in the Burke, Prichard, and Striped Peak Formations, Coeur d'Alene District

Element	Burke (402 samples)		Prichard (727 samples)		Striped Peak[a] (446 samples)		All Formations[b] (3,979 samples)	
	# of Valid Observations	90th Percentile	# of Valid Observations	90th Percentile	# of Valid Observations	90th Percentile	# of Valid Observations	90th Percentile
Antimony[c]	402	11	726	7.8	446	3.5	3,965	7.9
Arsenic[c]	393	19	726	40	445	20	3,969	24
Barium	402	903	727	708	446	878	3,979	1,085
Beryllium	402	2.2	727	2.9	446	2	3,979	2.4
Boron	402	110	727	105	446	115	3,979	166
Cadmium[d]	399	0.8	724	1.5	445	0.79	3,959	1.1
Calcium[e]	402	0.15	727	0.1	446	2	3,979	0.86
Chromium	402	46	727	80	446	61	3,979	60
Cobalt	402	11	727	18	446	16	3,979	15
Copper[d]	401	45	726	69	445	109	3,950	69
Iron[e]	402	6.2	727	7	446	7.2	3,979	6.9
Lanthanum	402	53	727	70	446	50	3,979	56
Lead[d]	402	216	727	125	446	58	3,979	140
Magnesium[e]	402	0.5	727	0.9	446	2	3,979	1.2
Manganese	402	2,086	727	1,083	446	1,844	3,979	2,508
Mercury[f]	401	0.09	701	0.1	434	1.1	3,922	0.14
Molybdenum	402	—	727	—	446	—	3,979	—
Nickel	402	21	727	29	446	29	3,979	25
Scandium	402	11	727	19	446	14	3,979	14
Silver[d]	401	1.2	725	1	445	0.6	3,961	1

Table 3.2-3 (Continued)
90th Percentile Distribution of Elements in Bedrock
in the Burke, Prichard, and Striped Peak Formations, Coeur d'Alene District

Element	Burke (402 samples)		Prichard (727 samples)		Striped Peak[a] (446 samples)		All Formations[b] (3,979 samples)	
	# of Valid Observations	90th Percentile	# of Valid Observations	90th Percentile	# of Valid Observations	90th Percentile	# of Valid Observations	90th Percentile
Strontium	402	—	727	—	446	—	3,979	—
Sulfur[e,g]	394	0.04	720	0.1	409	0.05	3,735	0.04
Titanium[e]	402	0.46	727	0.5	446	0.46	3,979	0.4
Vanadium	399	69	727	128	446	104	3,970	97
Yttrium	402	43	727	58	446	48	3,979	48
Zinc[d]	400	118	724	138	445	100	3,963	130
Zirconium	402	835	727	415	446	361	3,979	489

[a]In original publication (Gott and Cathrall 1980), "Striped Peak" was apparently mislabeled as "Belt."
[b]Includes monzonite stocks and all formations in Tables 3.2-2 and 3.2-3
[c]Colorimetric analysis
[d]Atomic absorption analysis
[e]In percent
[f]Mercury vapor detector analysis
[g]Leco combustion analysis

Notes:
Values are in parts per million except as indicated. Analyses are spectrographic unless otherwise indicated.
Dash indicates no data available.

Source: Gott and Cathrall 1980

Table 3.2-4
90th Percentile Distribution of Elements in Soils in the Monzonite Stocks and the Wallace, St. Regis, and Revett Formations, Coeur d'Alene District

Element	Monzonite (192 samples)		Wallace (2,298 samples)		St. Regis (1,586 samples)		Revett (699 samples)		All Formations[a] (8,713 samples)	
	# of Valid Observations	90th Percentile	# of Valid Observations	90th Percentile	# of Valid Observations	90th Percentile	# of Valid Observations	90th Percentile	# of Valid Observations	90th Percentile
Antimony[b]	192	3	2,178	5.3	1,544	7	693	5.7	8,153	5.8
Arsenic[b]	192	21	2,178	20	1,544	20	693	20	8,265	22
Barium	192	838	2,175	996	1,544	1,431	693	1,125	8,248	1,109
Beryllium	192	2.5	2,175	2.1	1,544	2.2	693	2	8,249	2.1
Boron	192	25	2,175	109	1,544	145	693	79	8,247	90
Cadmium[c]	192	2.2	2,142	1.7	1,480	2.8	654	2.3	7,167	2.7
Calcium[d]	192	0.92	2,175	1.1	1,544	1	693	0.9	8,249	1
Chromium	192	49	2,175	55	1,544	57	693	54	8,249	64
Cobalt	192	17	2,175	19	1,544	19	693	17	8,207	20
Copper[c]	177	65	2,293	47	1,584	60	698	53	8,695	53
Iron[d]	192	5.0	2,175	6.9	1,544	6.7	693	6.9	8,249	6.5
Lanthanum	192	50	2,175	47	1,544	45	693	51	8,249	48
Lead[c]	192	139	2,296	149	1,584	195	698	218	8,514	171
Magnesium[d]	192	0.80	2,175	1.1	1,544	1	693	0.8	8,249	1.1
Manganese	192	1,946	2,175	3,675	1,544	5,198	693	3,829	8,248	3,597
Mercury[e]	192	0.23	2,176	0.39	1,445	0.4	692	0.31	8,124	0.3
Molybdenum	—	—	—	—	—	—	—	—	—	—
Nickel	192	27	2,175	43	1,544	35	693	33	8,249	38
Niobium	—	—	2,000	13	1,255	11	553	11	7,530	12
Scandium	192	14	2,175	—	1,544	15	693	16	8,249	16

Table 3.2-4 (Continued)
90th Percentile Distribution of Elements in Soils
in the Monzonite Stocks and the Wallace, St. Regis, and Revett Formations, Coeur d'Alene District

Element	Monzonite (192 samples)		Wallace (2,298 samples)		St. Regis (1,586 samples)		Revett (699 samples)		All Formations[a] (8,713 samples)	
	# of Valid Observations	90th Percentile	# of Valid Observations	90th Percentile	# of Valid Observations	90th Percentile	# of Valid Observations	90th Percentile	# of Valid Observations	90th Percentile
Silver[c]	192	1.1	2,292	1.1	1,583	1.1	697	1	8,611	1.1
Strontium	192	518	2,175	265	1,544	275	693	282	8,249	276
Sulfur[d,f]	31	—	395	0.070	155	0.078	55	0.095	759	0.073
Titanium[d]	192	0.54	2,175	0.8	1,544	1	693	1	8,249	1
Vanadium	192	153	2,170	155	1,539	148	693	153	8,235	154
Yttrium	192	33	2,175	39	1,544	36	693	37	8,241	37
Zinc[c]	192	452	2,295	365	1,584	250	697	218	8,684	280
Zirconium	192	248	2,175	347	1,544	374	693	500	8,226	377

[a]Includes monzonite stocks and all formations in Tables 3.2-4 and 3.2-5
[b]Colorimetric analysis
[c]Atomic absorption analysis
[d]In percent
[e]Mercury vapor detector analysis
[f]Leco combustion analysis

Notes:
Values are in parts per million except as indicated. Analyses are spectrographic unless otherwise indicated.
Dash indicates no data available.

Source: Gott and Cathrall 1980

Table 3.2-5
90th Percentile Distribution of Elements in Soils
in the Burke, Prichard, and Striped Peak Formations, Coeur d'Alene District

Element	Burke (573 samples)		Prichard (1,705 samples)		Striped Peak[a] (987 samples)		All Formations[b] (8,713 samples)	
	# of Valid Observations	90th Percentile	# of Valid Observations	90th Percentile	# of Valid Observations	90th Percentile	# of Valid Observations	90th Percentile
Antimony[c]	564	4	1,442	8	987	2.3	8,153	5.8
Arsenic[c]	565	22	1,441	28	987	18	8,265	22
Barium	565	1,065	1,441	1,090	987	821	8,248	1,109
Beryllium	565	2.0	1,441	2.3	987	1.9	8,249	2.1
Boron	565	74	1,441	62	987	84	8,247	90
Cadmium[d]	559	1.9	1,440	5.7	987	1.2	7,167	2.7
Calcium[e]	565	1	1,441	0.98	987	1	8,249	1
Chromium	565	54	1,441	78	987	66	8,249	64
Cobalt	562	18	1,436	28	987	17	8,207	20
Copper[d]	476	31	1,586	37	987	49	8,695	53
Iron[e]	565	5.6	1,441	5.1	987	7	8,249	6.5
Lanthanum	565	47	1,441	51	987	50	8,249	48
Lead[d]	449	108	1,642	237	987	55	8,514	171
Magnesium[e]	565	0.84	1,441	0.86	987	1.5	8,249	1.1
Manganese	565	3,313	1,441	3,010	987	2,040	8,248	3,597
Mercury[f]	562	0.26	1,417	0.50	978	0.2	8,124	0.3
Molybdenum	—	—	—	—	—	—	—	—
Nickel	565	35	1,441	51	987	35	8,249	38
Niobium	490	12	1,423	15	987	11	7,530	12
Scandium	565	16	1,441	17	987	14	8,249	16
Silver[d]	567	1.1	1,632	1.1	986	0.9	8,611	1.1

Table 3.2-5 (Continued)
90th Percentile Distribution of Elements in Soils
in the Burke, Prichard, and Striped Peak Formations, Coeur d'Alene District

Element	Burke (573 samples)		Prichard (1,705 samples)		Striped Peak[a] (987 samples)		All Formations[b] (8,713 samples)	
	# of Valid Observations	90th Percentile	# of Valid Observations	90th Percentile	# of Valid Observations	90th Percentile	# of Valid Observations	90th Percentile
Strontium	565	310	1,441	256	987	214	8,249	276
Sulfur[e,g]	143	0.07	421	0.060	—	—	759	0.073
Titanium[e]	565	1	1,441	0.88	987	0.9	8,249	1
Vanadium	561	141	1,441	160	987	156	8,235	154
Yttrium	565	38	1,441	41	987	37	8,241	37
Zinc[d]	566	176	1,697	339	987	118	8,684	280
Zirconium	565	472	1,418	395	987	378	8,226	377

[a]In original publication (Gott and Cathrall 1980), "Striped Peak" was apparently mislabeled as "Belt."
[b]Includes monzonite stocks and all formations in Tables 3.2-4 and 3.2-5
[c]Colorimetric analysis
[d]Atomic absorption analysis
[e]In percent
[f]Mercury vapor detector analysis
[g]Leco combustion analysis

Notes:
Values are in parts per million except as indicated. Analyses are spectrographic unless otherwise indicated.
Dash indicates no data available.

Source: Gott and Cathrall 1980

Table 3.2-6
Analyses of Tetrahedrite From the Coeur d'Alene District

Element	Percent				
	Sunshine Mine[a]	Sunshine Mine[b]	Hypotheek Mine[c]	Sunshine Mine[d]	Sunshine Mine[e]
Antimony	22.36	22.36	26.81	25.90	26.1
Arsenic	10.13	8.59	Trace	1.18	—
Bismuth	0	0	Trace	0	—
Copper	29.10	29.10	37.70	33.70	26.2
Iron	5.50	5.50	5.13	5.05	—
Lead	0	0	0	0.20	—
Silver	3.95	6.15	Trace	5.75	11.12
Sulfur	24.16	24.44	26.49	24.10	—
Zinc	5.09	3.56	3.87	—	—
Total	100.29	99.70	100.0	95.88	—

[a]Source: Warren 1934, p. 694, analysis A.
[b]Source: Warren 1934, p. 694, analysis B.
[c]Source: Shannon 1926, p. 167.
[d]Source: Rasor 1934.
[e]Source: Mitcham 1952, p. 443.

Note:
Dash indicates no data available.

Source: Frykland 1964, p. 18, Table 9.

4.0 INVESTIGATION SUMMARY

Numerous studies to determine the extent of contamination and its potential impacts have been conducted by the mining companies, resource trustees, and others. Specific historical studies and data sets were selected for inclusion in this Remedial Investigation report based on their representativeness of current site conditions. Available data collected from 1989 through 2000 are considered representative of current conditions. Additionally, URS Greiner, Inc., USGS, and CH2M HILL collected additional soil, sediment, groundwater, and surface water samples on behalf of the USEPA beginning in 1997.

Previous investigations included in this Remedial Investigation report are summarized in Section 4.1. Remedial Investigation sampling activities conducted by URS Greiner, Inc., USGS and CH2M HILL are summarized in Section 4.2. Data used in the RI were managed in URS Greiner's Technical Data Management (TDM) electronic database. Tabulated data are included in Appendix A. Additional data sets relied upon in this report, but not tabulated in Appendix A, are discussed and referenced where appropriate.

4.1 PREVIOUS INVESTIGATIONS

This remedial investigation report relies on numerous sets of historical data collected by the EPA, U.S. Geological Survey, the U.S. Department of Interior, the University of Idaho, and others. Historical data used in this evaluation were selected from available data sources based on representativeness of current conditions of the study area. These data sources are listed in Table 4.1-1. A more comprehensive list of site characterization studies performed within the Basin is included for reference as Appendix H.

Specific data sets loaded into the project electronic database and used to support this investigation are listed in Table 4.1-1. Data sets are identified by source or originator (e.g., USGS). Specific numbers of each type of environmental sample associated with a specific source are listed (e.g., surface soil, groundwater).

As indicated, specific historical data sets were selected for inclusion in this investigation based on their representativeness of current site conditions and utility in filling in data gaps. It is not the intent or scope of this investigation to review all available data sets or collect and analyze environmental samples to fully characterize the Basin. The objective of this investigation is to compile and analyze available data, supplemented where necessary, sufficient to identify source areas of concern for further evaluation in the feasibility study. To meet this objective, historical data sets were combined with data collected by URS Greiner, Inc. As shown in Table 4.1-1, the historical data sets used in this investigation were gathered by numerous investigators to support investigations with different objectives; therefore, sample collection, preparation, and analysis methods are not identical and may not be comparable. A comprehensive evaluation of comparability was beyond the scope of this evaluation; however, during review of available data for specific geographic locations (e.g., Canyon Creek surface water), trends in chemical results indicative of comparability or other data quality issues were evaluated if identified and appropriate discussions added to the text.

4.2 REMEDIAL INVESTIGATION SAMPLING ACTIVITIES

Beginning in the fall of 1997, URS Greiner, Inc., and CH2M HILL collected additional soil, sediment, groundwater, surface water, and other environmental media (e.g., indoor dust, lead-based paint, garden produce) to support the Coeur d'Alene Basin remedial investigation. Fourteen separate field-sampling events were planned and performed. To guide field sampling efforts, a general field sampling plan and quality assurance project plan was prepared that included descriptions of methods that would be used to collect and analyze samples, conduct field measurements, and manage data (USEPA 1997). Fifteen project-specific sampling plans were developed as field sampling plan addenda (FSPAs) to the base plan. Each FSPA was developed to address specific data gaps identified after reviewing available historical data and results of previous field sampling and analysis efforts. FSPAs were developed in general accordance with the USEPA's Data Quality Objectives (DQOs) Process (USEPA 1994). Samples collected specifically to support the human health risk assessment (e.g., residential and common use area soil samples) were collected using statistically-based sampling designs. Samples collected to characterize source areas, groundwater, and surface water were selected after reviewing input from Coeur d'Alene basin experts and using best professional judgment (judgmental sampling strategy).

This section presents an overview of the remedial investigation data collection effort and includes a description of the DQO process (Section 4.2.1), how it was applied in the Coeur d'Alene Basin RI/FS process (Section 4.2.2), descriptions of each of the FSPAs (Section 4.2.3), and a summary of the use of the data collected for the remedial investigation (Section 4.2.4).

4.2.1 Data Quality Objectives Process

The DQO Process is a strategic planning approach based on the scientific method to prepare for a data collection activity (USEPA 1994). It provides a systematic procedure for defining the criteria that a data collection design should satisfy. This includes when to collect samples, where to collect samples, the tolerable level of decision error for the study, and how many samples to collect, balancing risk and cost in an acceptable manner. The Data Quality Assessment (DQA) Process is a comparison of the implemented sampling approach and resulting analytical data against the sampling and data quality requirements specified by the DQOs. The results meant to help determine whether the data are of adequate quality and quantity to support the decision-making process.

Using the DQO Process can help assure that the type, quantity, and quality of environmental data used in decision making will be appropriate for the intended application. The goal is to support environmental decisions that are technically and scientifically sound and defensible. In addition, the DQO Process help guard against committing resources to data collection efforts that do not support a defensible decision.

DQOs are qualitative and quantitative statements that:

- Clarify the study objective
- Define the most appropriate type of data to collect
- Determine the most appropriate conditions from which to collect the data
- Specify tolerable limits on decision errors that can be used as the basis for establishing the quantity and quality of data needed to support the decision

The DQOs are then used to develop a scientific and resource-effective data collection design.

The seven steps of the DQO Process are:

- **Step 1: State the Problem.** Concisely describe the problem to be studied. Review prior studies and existing information to gain a sufficient understanding to define the problem.

- **Step 2: Identify the Decision.** Identify what questions the study will attempt to resolve, and what actions may result.

- **Step 3: Identify the Inputs to the Decision.** Identify the information that needs to be obtained and the measurements that need to be taken to resolve the decision statement.

- **Step 4: Define the Study Boundaries.** Specify the time periods and spatial area to which decisions will apply. Determine when and where data should be collected.

- **Step 5: Develop a Decision Rule.** Define the statistical parameter of interest, specify the action level, and integrate the previous DQO outputs into a single statement that describes the logical basis for choosing among alternative actions.

- **Step 6: Specify Tolerable Limits on Decision Errors.** Define the decisionmaker's tolerable decision error rates based on a consideration of the consequences of making an incorrect decision. A decision error rate is the probability of making an incorrect decision based on data that inaccurately estimate the true state of nature.

- **Step 7: Optimize the Design for Obtaining Data.** Evaluate information from the previous steps and generate alternative data collection designs. Choose the most resource-effective design that meets all DQOs.

4.2.2 Application of the DQO Process in the Coeur d'Alene Basin RI/FS

When EPA began work that led to the preparation of this RI, contamination in the Coeur d'Alene basin had been under study since the 1930's, with work by others continuing to the present. Because of the large amount of existing information, the Coeur d'Alene Basin RI/FS relied as much as possible on existing data and identified data gaps as appropriate.

The decision to rely as much as possible on data already collected, or being collected by others, to complete the RI and FS lead to the need to do several things, each of which is discussed in greater detail later:

- Develop an understanding of the physical, chemical, and biological conditions of the Coeur d'Alene basin.

- Document and review existing information and data.
- Estimate what data were needed to perform a RI/FS for the Coeur d'Alene basin.
- Compare RI/FS data needs with the data available from other investigations and determine whether they could satisfy the RI/FS data needs.
- Evaluate the usability of data collected by other investigators.
- Identify additional data needs or "data gaps".
- Develop plans and methods for obtaining the additional data needed.
- Collect and analyze additional data.

At the time EPA began work covering the entire Coeur d'Alene basin, other federal agencies managing natural resources affected by mining waste contamination and the Coeur d'Alene Tribe (the NRDA Trustees) had been working for several years on intensive studies of metal contamination, and associated ecological effects in the basin. That work was supported in part by contractors for the NRDA Trustees, and by some studies done by the USGS in support of the other Federal agencies. The USGS had also performed studies of the Coeur d'Alene basin that were independent of their work with the NRDA Trustees.

The State of Idaho, under the Clean Water Act, had been collecting chemical and biological data within the basin for many years. The State of Washington had been collecting water and sediment quality data in the Spokane River. The mining companies or their contractors had been conducting studies and collecting data in several parts of the basin. Independent investigators, usually faculty or students at regional and national academic institutions, have also performed studies for various theses and dissertations, or contracted research starting in the 1970's, and continuing at present.

The steps in the DQO process described above were not conducted sequentially on this project. The activities were done simultaneously and iteratively through a series of meetings and workshops held to exchange information and ideas. The process followed was designed to comply with the intent of EPA's DQO guidance while also incorporating process design input from a large group of regulatory stakeholders. The process resulted in the development of individual sampling events designed to fill particular data needs for the project.

Because of the size and complexity of the Coeur d'Alene basin study area and the time constraints imposed by the schedule, it was decided that the review of existing data, the estimation of the data needs for the RI/FS, and the identification of data gaps, would be done through a series of meetings and workshops, as well as direct (person to person) contacts with other investigators who had worked in the Coeur d'Alene basin.

The initial meetings, held in Coeur d'Alene and Spokane in May, July, and August 1997, were mainly for the purpose of informing EPA about stakeholder perceptions of problems caused by mining waste, what previous studies and remedial work had been done, and what other studies or work were in progress or planned. In those meetings, data collected by others were presented to aid in understanding the chemical, physical, and biological conditions of the basin, and preliminary discussions were held regarding the actual sharing of data. During this time, EPA began developing the CSM as a framework for assembling the large amount of information expected, and also began preliminary consideration of how risks to humans and ecological resources in the basin would be evaluated and what type of remedial actions could be considered to correct adverse effects of mining waste. Preliminary work was performed to determine how human health and ecological risks would be evaluated to aid the remedial action decision process and identify data gaps to be filled in completing the RI/FS.

Following a series of meetings in mid-1997, the CSM was refined based on input from the stakeholders present at the previous meetings, and EPA began to assemble a range of management options or remedial technologies that might be applied. Between September 1997 and February 1998, a number of workshops and meetings were held to focus on specific physical, chemical and biological aspects of the basin ecosystem function, and on management options in the context of the CSM. In March 1998, the assembled information was presented at a workshop attended by EPA and stakeholders. The participants were asked to identify what data were needed to complete the RI/FS. The data-needs list was then prepared. Examples of how decisions would be made about the application of remedial technologies were presented at a workshop in April 1998. The participating stakeholders were asked to prioritize the data-needs list based on the examples presented. A considerably reduced list resulted from that prioritization. A focused meeting to identify significant source areas of continuing metals discharge in the basin was held in May 1998.

EPA evaluated the prioritized data-needs list in light of how they planned to perform the RI/FS, and arrived at a tiered approach for collecting additional data for the evaluation of the basin as a whole, and for evaluation of particular source areas that were identified by stakeholders and EPA. The tiered approach was driven in part by schedule (the need to do some field work before the basin became covered in snow) and in part by uncertainties regarding the amount of information that would actually be needed at particular source areas. Tier 1 activities were judged to be essential, and planned for immediate implementation. Tier 2 activities were those deemed necessary to supplement Tier 1 to achieve a higher level of precision, accuracy, ad reliability of information. Tier 2 activities were deferred until the data gathered in Tier 1 could be evaluated and the need for the Tier 2 data collection further evaluated. Tier 3 activities include treatability studies and could be performed as needed to determine the effectiveness, implementability, or cost of given cleanup alternatives.

EPA developed and implemented specific sampling and analysis plans for some of the Tier 1 activities. For others, it was judged that the work could be done more efficiently by the USGS and its subcontractors. In those cases, work plans, including sampling and analysis plans, were developed by USGS, reviewed by EPA, modified as needed, and implemented by the USGS.

Throughout the process described above, the issue of data quality was discussed in light of the different methods used by various investigators to collect and analyze samples and the relationships of those methods to procedures usually used in CERCLA investigations. Several things became apparent and were considered before deciding to use particular data sets:

- Quality control and assurance procedures varied among investigators, but all had some process in place.

- Several data sets included results generated from multiple methods of analysis. Those results provided a basis for comparing and benchmarking different analytical methods.

- The levels of metals contamination documented by various investigators were very large compared to levels that had been judged to be problematic at other metals-contaminated sites, further reducing concerns regarding the limited uncertainty range associated with the variety of analytical methods that had been used.

The seven-step DQO process was considered and documented in the Draft Technical Work Plan (URS Greiner and CH2M HILL 1998), and considered further and documented to varying degrees in individual FSPAs developed from 1997 through 2000.

Each FSPA and USGS task was developed to address specific data gaps identified after reviewing available historical data and results of previous sampling and analysis efforts. The purpose of each data collection effort was to investigate areas potentially impacted by mining-related activities. Due to the large geographic extent of the study area, it was not possible to fully characterize all areas.

More than 10,000 samples were collected to support the Remedial Investigation. These samples, combined with the 7,000 additional samples collected independently by IDEQ, USGS, the mining companies, EPA under other regulatory programs (e.g., NPDES), and others provide a solid basis to support informed risk management decisions for Coeur d'Alene Basin mining waste contamination. However, the large geographic area of the basin made it impractical to collect sufficient data to fully characterize each source area or watershed. Further data collection will be necessary to support remedial design for areas identified as requiring cleanup. This may include areas where previous cleanup actions have taken place, such as flood plain areas of the UPRR Right of Way (ROW) or other areas where previous removal actions have addressed some, but not all, contamination present.

This information is compiled in this RI report and carried forward into the human health and ecological risk assessments. Areas identified as having potential risk or as source areas of metals contamination are then evaluated further in the feasibility study. Since all data gaps have not been addressed, subsequent studies of specific areas identified for remedial actions may be needed to support remedial design efforts.

A combined field sampling plan and quality assurance project plan was developed in July 1997 to provide methods to be used to collect samples and make field measurements in support of the Coeur d'Alene Basin RI/FS (URS and CH2M HILL 1997).

Samples collected specifically to support the human health risk assessment (e.g., residential and common use area soil samples) were collected using statistically-based (i.e., probabilistic) sampling designs and were based on either systematic or random sampling strategies. Probabilistic sampling designs have a scientific basis for extrapolating results from a set of samples to an entire site or large areas of a site (USEPA 2000). In addition, they have an element of randomization, which allows probability statements to be made about the quality of the estimates (e.g., averages) derived from the data; therefore, probability samples are useful for testing hypotheses about whether a site is contaminated and estimating concentrations of contaminants. Probabilistic sampling design types include random, systematic and composite sampling.

Data needs to support the human health risk assessment were identified as described above and specific field efforts were chosen by consensus among the human health risk assessment stakeholder group consisting of the EPA, the State of Idaho, the Agency for Toxic Substances and Disease Registry (ATSDR), the Panhandle Health District, and the Coeur d'Alene Tribe. Sample collection designs were established to adequately determine the average concentrations of metals within the study boundaries. For the purposes of the human health risk assessment, study boundaries were either individual yards (residential sampling) or public areas (common use area sampling). The average surface soil concentration was the main statistical value of interest and as such, systematic, composite sampling methods were utilized in the yards while a randomized scheme was generally used for the public areas. For the residential sampling, sample design was based in part on work conducted in the BHSS so that results from the Basin would be comparable with BHSS results. The action levels were either site-specific levels applicable to recreational populations or derived from U.S. EPA Region 9 Preliminary Remediation Goals for residential populations. The potential for decision errors are discussed qualitatively in the uncertainty sections of the Human Health Risk Assessment documents (under separate cover).

Samples collected to characterize source areas, groundwater, and surface water were collected judgmentally. Nonprobabilistic sampling (i.e., judgmental sampling) approaches are developed when the project team selects specific sampling locations based on the investigators' experience or expert knowledge of the site. Typically, this is useful to confirm the existence of contamination at specific locations (e.g., source areas) based on visual or historical information. Judgmental samples can be used subjectively to provide information about specific areas of the site and is useful in site characterization when there is substantial information on the contamination sources and history (USEPA 2000). As presented in the Draft Technical Work Plan (URS Greiner and CH2M HILL 1998), historical source area, groundwater, and surface water data were reviewed when developing plans for additional data collection. Because reported metals concentrations were deemed to be much greater than applicable risk-based screening levels or available background concentrations, data generated using judgmental sampling designs were deemed to be of a level of quality sufficient to meet data quality objectives and confirm historical results. An analysis of the source area data set is included in Section 4.2.4.2.1. Data for seven source types were analyzed to determine the probability that the average arsenic, cadmium, lead, and zinc concentrations are greater than screening levels. In all except two cases, the probability that the average concentration is greater than screening levels is greater than 79 percent.

To clarify which type of sampling was performed (probabilistic or judgmental), sample types, sampling design, collection purpose, and data use are summarized for each FSPA and USGS task in Table 4.2.2-1.

4.2.3 Remedial Investigation Field Investigation Summaries

Data needs identified in the process described above were translated into purposes for the field sampling plans. Brief summaries of the sampling and analysis activities planned in each of the FSPAs completed by URS and CH2M HILL, and the ten USGS sampling and analysis tasks, are included in this section. Fifteen FSPAs were developed, numbered 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11A, 12, 13, 15, and 16. Numbers 11B and 14 were initially planned for but were not developed or performed. The matrix type, number of samples collected, collection dates, analytical laboratory, and analytical methods requested for each FSPA are summarized in Tables 4.2.3-1 through 4.2.3-3.

4.2.3.1 FSPA No. 1

The field work conducted under FSPA No. 1 consisted of geophysical surveys and sediment core sampling within the lower Coeur d'Alene River basin. The sediment core samples were collected from the main stem of the lower Coeur d'Alene River, Lateral Lakes, and the Coeur d'Alene River floodplain. The purpose, scope, and summary of field activities and laboratory analyses are summarized below. Modifications to the previously published FSPA are provided in Appendix J.

4.2.3.1.1 Purpose. The purpose of this sampling effort was to collect data to define the vertical extent of mining waste deposits within the Coeur d'Alene River main stem, the Lateral Lakes, and the Coeur d'Alene River floodplain. Data were also collected to estimate the impacts to the ecosystem if dredging actions are implemented. The data collected will be used to estimate the volume of sediments within the lower Coeur d'Alene River basin that is contaminated with mining waste. These volume estimates will be used in developing and evaluating remedial alternatives in the feasibility study.

4.2.3.1.2 Scope. The scope of FSPA No. 1 was described in the *Field Sampling Plan and Quality Assurance Project Plan Addenda for the Bunker Hill Basin-Wide RI/FS, Addenda 01, Sediment Coring in the Lower Coeur d'Alene River Basin, including the Lateral Lakes and River Floodplain* (U.S. EPA 1997). Modifications to the planned scope were made in the field during the sampling activities. These modifications are documented in the *Field Sample Plan Alterations for the Bunker Hill Facility/Coeur d'Alene Basin Project, Shoshone County, Idaho* (U.S. EPA 1998).

4.2.3.1.3 Summary of Field Activities and Laboratory Analyses. The field activities conducted as part of FSPA No. 1 are summarized in this section. The field activities conducted as part of the geophysical/bathymetry survey and the coring survey are discussed in the following sections.

Geophysical/Bathymetric Survey. The geophysical/bathymetric survey was conducted in six areas: Cataldo, Dudley, Killarney, Medimont, Swan, and Harrison. The survey was performed along 3 transects in the Cataldo area, 11 transects in the Dudley area, 8 transects in the Killarney area, 6 transects in the Medimont area, 6 transects in the Swan area, and 6 transects in the Harrison area. Therefore, a total of 40 transects were surveyed using geophysics and bathymetry. Geophysical and bathymetric data were collected at multiple locations or measuring points along each transect. Data were collected at a total of 803 locations or measuring points. The geophysical and bathymetric data were collected at 50 locations in the Cataldo area, 176 locations in the Dudley area, 133 locations in the Killarney area, 153 locations in the Medimont area, 142 locations in the Swan area, and 149 locations in the Harrison area. A summary of the geophysical/bathymetric activities is included in Table 4.2.3-4. Detailed information on the geophysical/bathymetric survey is included in the sediment data report (U.S. EPA 1998e).

Coring Survey. A total of 99 cores were obtained during this field effort. Of these 99 cores, 31 cores were obtained from the main stem of the Coeur d'Alene River, 20 cores from the Lateral Lakes, and 48 cores from the floodplain. Eight of the Coeur d'Alene River main stem cores were obtained for the USGS and two were archive cores. In addition, four of the Lateral Lakes cores were archive cores. Therefore, samples were obtained from only 85 cores. A total of 302 samples were collected for analysis of which 275 were environmental samples and 27 were field duplicates.

A summary of the quantity of samples collected as part of the FSPA No. 1 core sampling is provided in Table 4.2.3-5. Site and location information and sample data are provided in Appendix A. The sample locations are shown in figures in the Nature and Extent Section (Part 3, Section 4).

4.2.3.2 FSPA No. 2

The field work conducted under FSPA No. 2 consisted of sampling and analysis of mine adit drainage, tailings seeps, and stream water during the fall 1997 low flow event. The purpose, scope, and summary of field activities and laboratory analyses are summarized below. Modifications to the previously published FSPA are provided in Appendix J.

4.2.3.2.1 Purpose. The purpose of this sampling event was to identify potential sources of metals to the Coeur d'Alene River from previously unknown sources. In addition, selected tributaries of the South Fork that had not been previously sampled were sampled to identify sources upstream on the tributary. Similar surface water sampling had been performed in the past by McCulley, Frick, and Gilman, Inc. (MFG 1991, 1992), the Idaho Department of Environmental Quality (IDEQ), and Golder Associates. Therefore, this sampling effort was used to supplement existing data for the Coeur d'Alene River basin (i.e. fill data gaps), to provide current surface water quality and stream flow data, and to evaluate changes to the surface water quality over time. The data collected were used to estimate metal mass loading in the Coeur d'Alene River system and in the identification and selection of remedial actions. This sampling effort also serves as a baseline against which future sampling results may be compared. The effectiveness of on-going or completed remedial activities may be assessed by comparing future monitoring data to data from this baseline event.

4.2.3.2.2 Scope. The scope of FSPA No. 2 was described in the *Field Sampling Plan and Quality Assurance Project Plan Addenda for the Bunker Hill Basin-Wide RI/FS, Addenda 2, Adit Drainage, Seep and Creek Surface Water Sampling* (U.S. EPA 1997). Modifications to the planned scope were made in the field during the sampling activities. These modifications are documented in the *Field Sampling Plan Alterations for the Bunker Hill Facility/Coeur d'Alene Basin Project, Shoshone County, Idaho* (U.S. EPA 1998).

4.2.3.2.3 Summary of Field Activities and Laboratory Analyses. The field sampling activities conducted as part of FSPA No. 2 are summarized in this section. The results for the surface water creek/river sampling and the adit drainage and seep surface water sampling are provided in more detail below. A summary of the quantity of samples collected as part of FSPA No. 2 is provided in Table 4.2.3-6.

Flow measurements and field parameter measurements were also obtained at each surface water sampling location. Field parameter measurements included temperature, pH, ORP, conductivity, DO, and turbidity. Location information and sample information is provided in Appendix A. The sampling locations are shown in figures in the nature and extent sections.

Task 1—Surface Water Creek/River Sampling. A total of 115 locations were sampled in November of 1997 as part of the surface water creek/river low flow sampling event: 24 locations on the South Fork, 43 locations on South Fork tributaries, 16 locations on Canyon Creek, 16 locations on Ninemile Creek, 9 locations on Pine Creek, and 7 downstream locations. Nine locations along Canyon Creek were resampled in January of 1998 after the Canyon Creek construction activities had ceased. As a result, 117 environmental samples were collected along the South Fork and its tributaries and 7 environmental samples at downstream locations. In addition, 13 field duplicate samples were collected. Therefore, a total of 137 samples were collected.

Task 2—Adit Drainage and Seep Surface Water Sampling. A total of 44 adits and seeps were sampled as part of the low flow sampling event. Seven environmental samples were collected from seeps and adits along the upper South Fork, 4 environmental samples were collected from seeps and adits along Canyon Creek, 11 environmental samples were collected from seeps and adits along Ninemile Creek, 6 environmental samples were collected from seeps and adits along the lower South Fork, and 16 environmental samples were collected from seeps and adits along Pine Creek. In addition, two field duplicate samples were collected. Therefore, a total of 46 samples were collected.

4.2.3.3 FSPA No. 3

The field work conducted under FSPA No. 3 consisted of sampling and analysis of sediments along transects within the South Fork from Larson to Kellogg and along Ninemile Creek, Canyon Creek, and Pine Creek. The purpose, scope, and summary of field activities and laboratory analyses are summarized below. Modifications to the previously published FSPA are provided in Appendix J.

4.2.3.3.1 Purpose. The purpose of this sampling event was to supplement existing data to estimate transport of mine-impacted river bottom sediments and to estimate the volume of mine-impacted sediments in the river and creek floodplain. In addition, data collected was to be used to estimate metal bioavailability and toxicity potential, to relate sediment texture to metal burden, and to estimate metal scavenging by organic carbon in the sediments.

4.2.3.3.2 Scope. The scope of FSPA No. 3 was described in the *Field Sampling Plan and Quality Assurance Project Plan Addenda for the Bunker Hill Basin-Wide RI/FS, Addenda 03, Sediment Sampling Survey in the South Fork of the Coeur d'Alene River, Canyon Creek, and Nine-Mile Creek* (U.S. EPA 1997). Modifications to the planned scope were made in the field during the sampling activities. These modifications are documented in the *Field Sample Plan Alterations for the Bunker Hill Facility/Coeur d'Alene Basin Project, Shoshone County, Idaho* (U.S. EPA 1998).

4.2.3.3.3 Summary of Field Activities and Laboratory Analyses. A total of 40 transects were sampled during this field effort and a total of 141 samples were collected for analysis of which 129 were environmental samples and 12 were field duplicates.

A summary of the quantity of samples collected as part of FSPA No. 3 is provided in Table 4.2.3-7. Site and location information and sample information is provided in Appendix A. The sampling locations are shown in figures in the nature and extent section (Part 3, Section 4).

4.2.3.4 FSPA No. 4

The field work conducted under FSPA No. 4 consisted of sampling and analysis of mine adit drainage, tailings seeps, and stream water during the spring (May) 1998 high-flow event. Sampling occurred on the South Fork, Canyon Creek, Ninemile Creek, Pine Creek, and other tributaries of the South Fork. The sampling in Pine Creek, Canyon Creek, and Ninemile Creek was coordinated with sampling being performed by the U.S. Geological Survey (USGS). In addition, soil sampling was performed at the Golconda Mine site. The purpose, scope, and summary of field activities and laboratory analyses are summarized below. Modifications to the previously published FSPA are provided in Appendix J.

4.2.3.4.1 Purpose. The purpose of this sampling event was to identify potential sources of metals to the Coeur d'Alene River from previously unknown sources. Similar surface water sampling had been performed in the past by McCulley, Frick & Gilman, Inc. (MFG 1991, 1992), IDEQ, and Golder Associates. Therefore, this sampling effort was used to supplement existing data for the Coeur d'Alene River basin (i.e. fill data gaps), to provide current surface water quality and stream flow data, and to evaluate surface water quality data as a function of time. The data collected will be used to estimate metal mass loading in the Coeur d'Alene River system and it will be used in the identification and selection of remedial actions. This sampling effort also serves as a baseline against which future sampling results may be compared. The effectiveness of on-going or completed remedial activities may be assessed by comparing future monitoring data to data from this baseline event.

4.2.3.4.2 Scope. The scope of FSPA No. 4 was described in the *Draft Field Sampling Plan and Quality Assurance Project Plan Addenda for the Bunker Hill Basin-Wide RI/FS, Addenda 4, Adit Drainage, Seep and Creek Surface Water Sampling; Spring 1998 High Flow Event* (U.S. EPA 1998a). Prior to initiating field efforts, this scope was modified by *Field Sample Plan Alteration for the Adit Drainage, Seep, and Creek Surface Water Sampling; Spring 1998 High Flow Event* (U.S. EPA 1998b). Modifications to the planned scope were made in the field during the sampling activities. These modifications are documented in the *Field Sampling Plan Alterations for the Adit Drainage, Seep, and Creek Surface Water Sampling; Spring 1998 High Flow Event* (U.S. EPA 1998c).

4.2.3.4.3 Summary of Field Activities and Laboratory Analyses. The field sampling activities conducted as part of FSPA No. 4 are summarized in this section and in Table 4.2.3-8. The results for the surface water creek/river sampling, the adit drainage and seep surface water sampling, and the Golconda Mine site soil sampling are provided in more detail below.

Flow measurements and field parameter measurements were also obtained at each surface water sampling location. Field parameter measurements included temperature, pH, ORP, conductivity, DO, and turbidity. The soil samples were analyzed for total metals (CLP) by SVL Analytical of Kellogg, Idaho. Location information and sample information is provided in Appendix A. The sampling locations are shown in figures in the nature and extent section.

Task 1—Surface Water Creek/River Sampling. A total of 200 samples were collected as part of the surface water creek/river high flow sampling event. One hundred and twenty one environmental samples were collected along the South Fork and its tributaries, 46 along the North Fork, and 7 at downstream locations. In addition, 17 field duplicate samples were collected, and USGS collected 9 environmental samples.

Task 2—Adit Drainage and Seep Surface Water Sampling. A total of 47 adit and seep samples were collected as part of the high flow sampling event. Twelve environmental samples were collected from seeps and adits along the upper South Fork, 6 from seeps and adits along Canyon Creek, 9 from seeps and adits along Ninemile Creek, 2 from seeps and adits along the lower South Fork, and 14 from seeps and adits along Pine Creek. In addition, four field duplicate samples were collected.

Task 3—Golconda Mine Site Samples. A total of 24 soil samples were collected from nine locations at the Golconda Mine site.

4.2.3.5 FSPA No. 5

The field work conducted under FSPA No. 5 consisted of sampling and analysis of playground, parks, and other common use area soils; beach sand (sediment) and shallow surface water; and, if appropriate, the drinking water supply from the common use areas (CUAs). The purpose, scope, and summary of field activities and laboratory analyses are summarized below. Modifications to the previously published FSPA are provided in Appendix J.

4.2.3.5.1 Purpose. The purpose of the FSPA No. 5 sampling event was to provide data to differentiate areas not impacted by mining activities from areas impacted by mining activities. The data were also to be used to assess the risks to human health and to identify appropriate remedial measures at those areas found to be impacted. The data may also be used in the ecological risk assessment; however, reporting limits and constituents studied are based on human health risk assessment needs.

4.2.3.5.2 Scope. The scope of FSPA No. 5 was described in the *Field Sampling Plan and Quality Assurance Project Plan Addenda for the Bunker Hill Basin-Wide RI/FS, Addendum 05, Common Access Areas: Upland Common Use Areas and Lower Basin Recreational Beaches; Sediment/Soil, Surface Water, and Drinking Water Supply Characterization* (U.S. EPA 1998a), *Field Sampling Plan Addendum 05 Errata* (U.S. EPA 1998b), and *FSPA 05 -- Amended Site-Specific Sample Plans, Sites 80, 95, and 100* (U.S. EPA 1998c). Modifications to the planned scope were made in the field during the sampling activities. These modifications are documented in the *Draft Field Sampling Plan Alterations, Bunker Hill Basin-Wide RI/FS, Shoshone County, Idaho, Addendum 05, Common Access Areas: Upland Common Use Areas and Lower Basin Recreational Beaches; Sediment/Soil, Surface Water, and Drinking Water Supply Characterization* (U.S. EPA 1999).

4.2.3.5.3 Summary of Field Activities and Laboratory Analyses. The field sampling activities performed as part of FSPA No. 5 are summarized in this section. A discussion of the sediment/soil sampling, the surface water sampling, and the drinking water sampling are provided in more detail below. At total of 71 CUAs were sampled from July through September 1998 during this field effort and a total of 2,174 samples were collected and analyzed of which 1,955 were environmental samples and 219 were field duplicates. Summaries of the quantity of samples collected as part of the FSPA No. 5 common use area sampling are provided in Tables 4.2.3-9, 4.2.3-10, and 4.2.3-11.

Site and location information and sample information are provided in Appendix A. The sampling locations are shown on figures in the nature and extent sections of the RI report.

Task 2—Sediment/Soil Sampling. Wet beach sediment, dry beach sediment, and soil samples were collected as part of the sediment/soil sampling. A total of 1,849 sediment/soil samples were collected from 71 CUAs of which 1,664 were environmental samples and 185 were field duplicates (see Table 4.2.3-9). 421 sediment/soil samples were collected from the CUAs along the Spokane River and Lake Coeur d'Alene, 408 sediment/soil samples were collected from the CUAs along the Coeur d'Alene River, and 1,020 sediment/soil samples were collected from the CUAs along the South Fork.

Wet beach sediment samples were collected from 47 CUAs. A total of 287 wet beach samples were collected of which 261 were environmental samples and 26 were field duplicates. A total of 155 wet beach samples were collected from the CUAs along the Spokane River and Coeur d'Alene Lake, 122 wet beach samples from the CUAs along the Coeur d'Alene River, and 10 wet beach samples from the CUAs along the South Fork. Dry beach sediments were collected from 38 CUAs. A total of 293 dry beach sediment samples were collected of which 263 were environmental samples and 30 were field duplicates. 166 dry beach samples were collected from the CUAs along the Spokane River and Coeur d'Alene Lake, 110 dry beach samples were collected from the CUAs along the Coeur d'Alene River, and 17 dry beach samples were collected from the CUAs along the South Fork. Sediment samples, wet and dry combined, were collected from 48 CUAs. A total of 580 sediment samples were collected of which 524 were environmental samples and 56 were field duplicates. Therefore, 321 sediment samples were collected from the CUAs along the Spokane River and Coeur d'Alene Lake, 232 sediment samples were collected from the CUAs along the Coeur d'Alene River, and 27 sediment samples were collected from the CUAs along the South Fork.

Soil samples were collected from 58 CUAs. A total of 1,269 soil samples were collected, of which 1,140 were environmental samples and 129 were field duplicates. One hundred soil samples were collected from CUAs along the Spokane River and Coeur d'Alene Lake, 176 soil samples were collected from the CUAs along the Coeur d'Alene River, and 993 soil samples were collected from the CUAs along the South Fork.

Task 3—Surface Water Sampling. A total of 321 surface water samples were collected from 48 CUAs, of which 287 were environmental samples and 34 were field duplicates (see Table 4.2.3-10). One hundred seventy-nine surface water samples were collected from the Spokane River and Coeur d'Alene Lake, 130 surface water samples were collected from the Coeur d'Alene River, and 12 surface water samples were collected from the South Fork.

Task 4—Drinking Water Sampling. A total of four drinking water samples were collected from four CUAs, all of which were environmental samples (see Table 4.2.3-11). Two surface water samples were collected from CUAs along the Spokane River and Coeur d'Alene Lake and two samples were collected from CUAs along the Coeur d'Alene River.

4.2.3.6 FSPA No. 6

The field work conducted under FSPA No. 6 consisted of sampling and analysis of residential yard soil, garden produce, residential drinking water, indoor dust, and other potential human exposure media, if present. Sampling was only performed at residences outside of the Bunker Hill Superfund Site. The purpose, scope, and summary of field activities and laboratory analyses for this sampling event are summarized below. Modifications to the previously published FSPA are provided in Appendix J.

4.2.3.6.1 Purpose. The purpose of the field sampling effort at residential sites was to provide data for the human health risk assessment (HHRA). The HHRA calculated conservative risk estimates across residential areas in the Coeur d'Alene River basin that may have been adversely affected by past mining activities. These human health risk estimates were used to evaluate the necessity of a response action at a site or group of sites and to help guide the development of remedial alternatives, if necessary.

The purpose of sampling yard soil was to gather data to evaluate direct exposure pathways for residents while playing, gardening, or engaging in other activities in their yards. Yard soil is also known to substantially contribute to the accumulation of indoor dust, which is a significant exposure pathway for small/young children. Therefore, samples were collected from residential yards to determine whether yard soil is a source of potential exposure to contaminants during outdoor activities or a source of contaminated indoor dust.

The purpose of sampling garden produce was to verify the concentrations of inorganics used in the HHRA. The inorganic concentrations in garden produce were to be estimated for the HHRA based on using inorganic concentrations measured in soil plant uptake modeling. The estimated inorganic concentrations in plants used in the HHRA were then to be compared to the analytical results obtained from the garden produce sampling to verify the validity of the plant soil uptake model. The purpose of sampling residential drinking water was to evaluate whether drinking water is an additional source of exposure to elevated concentrations of inorganics. The analytical results for drinking water were compared to "immediate action" screening levels and used in the HHRA. The purpose of sampling indoor dust was to evaluate human health risks due to the incidental ingestion of contaminated household dust. The indoor dust sampling included sampling door mats, vacuum cleaner bags, and paint chips.

4.2.3.6.2 Scope. The scope of FSPA No. 6 was described in the *Field Sampling Plan and Quality Assurance Project Plan for the Bunker Hill Basin-Wide RI/FS, Addendum No. 6, Residential Sampling to Support the Human Health Risk Assessment* (U.S. EPA 1998e). Modifications are documented in the *Draft Field Sampling Plan Alterations for Bunker Hill Basin-Wide RI/FS Shoshone County, Idaho, Addendum 06, Residential Sampling to Support the Human Health Risk Assessment* (U.S. EPA 1999c).

4.2.3.6.3 Summary of Field Activities and Laboratory Analyses. The field sampling activities conducted as part of FSPA No. 6 are summarized in this section. Location information for this sampling event is confidential and, therefore, not included in this report. A summary of the quantity of samples collected during September and October 1998 as part of FSPA No. 6 residential sampling is provided in Table 4.2.3-12 and sample information is provided in Appendix A.

Task 1—Outdoor Soils (Yard Soils). A total of 80 residential yards were sampled during this field effort. Soils from play areas, garden plots, and lawn/open areas were sampled at 79 residences, and soils from high-biased areas were sampled at 73 residences. A total of 2,041 samples were collected for analysis of which 1,822 samples were environmental and 219 were field duplicates. From the play areas, garden plots, lawn/open areas, 1,800 samples were collected of which 1,642 were environmental samples and 158 were field duplicates. From the high-biased areas, 241 samples were collected of which 180 were environmental samples and 61 were field duplicates.

Task 2—Garden Produce. Garden produce samples were collected from 27 residences. Twenty-six samples of leafy vegetables were collected of which 25 were environmental samples and 1 was a field duplicate. Twenty-one samples of root vegetables were collected of which 20 were environmental samples and 1 was a field duplicate. Of the 26 samples of leafy vegetables collected, nine could not be analyzed because of an insufficient quantity of sample. Of the 21 samples of below ground vegetables collected, one could not be analyzed because of an insufficient quantity of sample. Therefore, only 37 samples were analyzed of which 35 were environmental samples and 2 were field duplicates.

Task 3—Drinking Water. Drinking water samples were collected from 89 residences, for a total of 194 samples of which 178 were environmental samples and 16 were field duplicates. Half of the samples were static water samples and the other half were purged water samples.

Task 4—Indoor Dust. Indoor dust samples were collected from 87 residences. Floor mat samples were collected from 84 residences, vacuum cleaner bag samples were collected from 77 residences, and paint chip samples were collected from 41 residences. A total of 235 indoor dust samples were collected of which 212 were environmental samples and 23 were field duplicates. Ninety-six floor mat samples were collected of which 84 were environmental samples and 12 were field duplicates. Eighty-four vacuum cleaner bag samples were collected of which 77 were environmental samples and 7 were field duplicates. Fifty-five paint chip samples were collected of which 51 were environmental samples and 4 were field duplicates.

Task 5—Other Potential Exposure Media. One additional potential exposure medium (sediment) was identified at three residences. At one residence, the sediment was from the floodplain of a dry stream. At one residence, the sediment was from a lake beach, and at one residence the sediment was from a stream bank. A total of four sediment samples were collected of which three were environmental samples and one was a field duplicate.

4.2.3.7 FSPA No. 7

The field work conducted under FSPA No. 7 consisted of sampling and analysis of residential yard soil. Sampling was only performed at residences outside of the Bunker Hill Superfund Site. The purpose, scope, and summary of field activities and laboratory analyses for this sampling event are summarized below. Modifications to the previously published FSPA are provided in Appendix J.

4.2.3.7.1 Purpose. The purpose of the sampling effort under FSPA No. 7 was to conduct fast-track sampling of residential yards at homes that had not been sampled previously and that met one of the following conditions:

- A child below the age of 7 living in the residence
- A child in the home with a blood lead level greater than or equal to 10 μg/dl
- A pregnant woman living in the residence

The fast-track sampling effort was used to identify yards for potential remedial action and to determine if the yards should be included in the more intensive HHRA sampling effort performed under FSPA No. 6.

4.2.3.7.2 Scope. The scope of FSPA No. 7 was described in the *Final Field Sampling Plan and Quality Assurance Plan for the Bunker Hill Facility/Coeur d'Alene Project, Shoshone County, Idaho, Addendum 07, Fast Track Sampling of Residential Yards in the Coeur d'Alene Basin* (USEPA 1998). Modifications are documented in the *Draft Field Sampling Plan Alterations, Bunker Hill, Basin-Wide RI/FS, Shoshone County, Idaho, Addendum 07, Fast Track Sampling of Residential Yards in the Coeur d'Alene Basin* (USEPA 1999).

4.2.3.7.3 Summary of Field Activities and Laboratory Analyses. The field sampling activities performed under FSPA No. 7 are summarized in this section. Location information for this sampling event is confidential and is, therefore, not included in this report. A summary of the quantity of samples collected as part of FSPA No. 7 sampling is provided in Table 4.2.3-13. A total of 19 residences were sampled in July 1998 during this field effort and a total of 228 samples were collected for analysis of which 206 were environmental samples and 22 were field duplicates.

Lawn/Open Areas. Lawn/open areas (location 101) were sampled at a total of 19 residences. A total of 108 samples were collected for analysis of which 94 were environmental samples and 14 were field duplicates.

Gravel Driveways. Gravel driveways/parking areas/walkways (location 102) were sampled at a total of 13 residences. A total of 43 samples were collected for analysis of which 40 were environmental samples and 3 were field duplicates.

Child's Play Areas. Play areas (location 103) were sampled at a total of six residences. A total of 25 samples were collected for analysis of which 24 were environmental samples and 1 was a field duplicate.

Garden Plots. Garden plots (location 104) were sampled at a total of seven residences. A total of 23 samples were collected for analysis of which 21 were environmental samples and 2 were field duplicates.

Other Discrete Areas. Other discrete areas (locations 105, 106, and 120) were sampled at a total of seven residences. A total of 28 samples were collected for analysis of which 26 were environmental samples and 2 were field duplicates. Ten of the samples were from secondary gravel driveways/parking areas/walkways; four were from an adjacent lot; five were from a secondary child's play area; four were from a secondary garden area; one was from a sand pile; and four were from an unimproved area. In addition to locations 105, 106, and 120; a sample was obtained from a black crystalline material (crushed slag pipe bedding) at one residence (location 201).

4.2.3.8 FSPA No. 8

This field sampling effort addressed data needs for the Tier 2 source areas. Tier 2 source areas are those areas where subsurface investigation was considered necessary and practicable. The field work conducted under FSPA No. 8 consisted of installation of exploratory boreholes/monitoring wells, piezometers, and test pits. Sampling and analysis of soil samples from the exploratory boreholes, of groundwater samples from the monitoring wells, of surface soil samples from floodplain and waste pile locations, and of surface water samples from rivers and streams was performed in November and December 1998. In addition, a geomorphic evaluation was to be performed at various locations along Canyon Creek and Ninemile Creek. The purpose, scope, and summary of field activities and laboratory analyses are summarized below. Modifications to the previously published FSPA are provided in Appendix J.

4.2.3.8.1 Purpose. The purpose of this sampling event was to provide chemical and physical data for areas within the South Fork Coeur d'Alene River basin (South Fork) primarily upstream of the Bunker Hill Superfund site. In particular, these data were to provide needed physical or chemical characteristics of the source area features (i.e., waste piles, valley fill and embankments, adit drainages, and seeps), stream geomorphology and groundwater characteristics, and hydraulic parameters of groundwater and streams. The information collected will be used to help characterize potential source areas, select appropriate remedial alternatives for source areas that potentially require remediation, and evaluate remedial alternatives.

4.2.3.8.2 Scope. The scope of FSPA No. 8 was described in the *Draft Field Sampling Plan for the Bunker Hill Basin-Wide RI/FS, Addendum No. 8, Tier 2 Source Area Characterization Field Sampling Plan* (U.S. EPA 1998a) and eight technical memoranda (URSGWC 1998a,b,c,d,e,f,g,h). Modifications to the planned scope were made in the field during the sampling activities. These modifications are documented in the *Field Sampling Plan Alterations, Bunker Hill Basin-Wide RI/FS, Shoshone County, Idaho* (U.S. EPA 1998b).

4.2.3.8.3 Summary of Field Activities and Laboratory Analyses. The field sampling activities are summarized in this section. The results for the exploratory boreholes, monitoring wells, ground surface sampling, river and stream water sample collection, and other tasks are provided in more detail below. Location information and sample information are provided in Appendix A. The sample locations are shown in figures in the nature and extent section (Part 3, Section 4).

Task 1—Exploratory Boreholes. A total of 34 exploratory boreholes were drilled at Canyon Creek, 8 at Ninemile Creek, and one at Pine Creek. Therefore, 43 exploratory boreholes were drilled as part of Task 1. Forty-one of these boreholes were sampled. Two were not sampled. A total of 82 subsurface soil samples were collected, of which 77 were environmental samples and 5 were field duplicates. Sixty-five samples were collected from along Canyon Creek, 15 samples from along Ninemile Creek, and 2 samples from along Pine Creek. A summary of the samples collected is provided in Table 4.2.3-14.

Task 2—Monitoring Wells. Monitoring wells were installed in all exploratory boreholes drilled as part of Task 1. Thirty-four monitoring wells were installed at Canyon Creek, 8 at Ninemile Creek, and 1 at Pine Creek, for a total of 43. Of these monitoring wells, 40 were sampled. Three could not be sampled because they were dry. In addition, one domestic water supply well was sampled (PC101). Therefore, a total of 41 wells were sampled at different depths. A total of 90 water samples were collected from these wells of which 83 were environmental samples and 7 were field duplicates. Sixty-nine samples were collected from monitoring wells along Canyon

Creek, 18 samples from monitoring wells along Ninemile Creek, 4 samples from a monitoring well along Pine Creek, and 1 sample from the domestic water supply well. A summary of the samples collected is provided in Table 4.2.3-15.

Task 3—Ground Surface Sampling. Surface soil samples were collected from 22 locations on Canyon Creek, 17 locations on Ninemile Creek, and 5 locations on the South Fork (Old Mullan Dump). A total of 49 surface soil samples were collected, of which 44 were environmental samples and 5 were field duplicates. Twenty-five samples were collected from locations along Canyon Creek, 18 samples from locations along Ninemile Creek, and 6 samples from the Old Mullan Dump. A summary of the samples collected is provided in Table 4.2.3-16.

Task 4—River and Stream Water Sample Collection. Surface water samples were collected from 26 locations on Canyon Creek, 27 locations on Ninemile Creek, 5 locations on the South Fork (McFarren Gulch), and 2 locations on Pine Creek. Several locations were sampled more than once. Therefore, a total of 79 samples were collected, of which 72 were environmental samples and 7 were field duplicates. Thirty-seven samples were collected on Canyon Creek, 34 samples on Ninemile Creek, 6 samples on McFarren Gulch, and 2 samples on Pine Creek. A summary of the samples collected in provided in Table 4.2.3-17.

Other Tasks—Piezometers, Test Pits, and Geomorphic Evaluation. Five test pits were installed, as planned, at the Success Mine waste rock pile. Piezometers were installed in all five test pits (NM424, NM425, NM426, NM427, NM428). In addition, piezometers were installed at two other locations: one in Canyon Creek (CC1000) and one in Ninemile Creek (NM1001). Soil samples were collected and archived during the installation of the test pits. No samples were collected during or after installation of the piezometers.

The geomorphic evaluation was performed at Canyon and Ninemile Creeks, and observations were recorded in a logbook.

4.2.3.9 FSPA No. 9

The field work conducted under FSPA No. 9 consisted of aerial photogrammetry, hyperspectral imaging, field screening using x-ray fluorescence (XRF), and surface water sampling. The purpose, scope, and summary of field activities and laboratory analyses are summarized below. Because the hyperspectral imaging results are not used in the RI, a summary of these activities is not included in this section. Modifications to the previously published FSPA are provided in Appendix J.

4.2.3.9.1 Purpose. The purpose of this sampling effort was to collect data to identify and characterize potential mining-related contaminant sources located in the Coeur d'Alene River basin. In particular, this field sampling effort was performed to:

- Provide data to verify/reject/refine the existence and locations of potential mining-related contaminant sources including those in relatively inaccessible areas.
- Provide accurate topography of the contaminant sources and the surrounding ground surfaces, suitable for estimating volumes and surface areas in the feasibility study.
- Provide accurate topography to evaluate geotechnical stability, surface slope and erosion potential, hydrogeology, watershed boundaries, and surface water hydrology.
- Provide information needed to assess the accessibility of a site.
- Provide data on the types and concentrations of contaminants in or on potential contaminant sources.
- Provide a snapshot of basin-wide conditions at the time of the field effort.

4.2.3.9.2 Scope. The scope of FSPA No. 9 was described in the *Field Sampling Plan and Quality Assurance Project Plan Addenda for the Bunker Hill Basin-Wide RI/FS, Addenda 09, Delineation of Contaminant Source Areas in the Coeur d'Alene Basin using Survey and Hyperspectral Imaging Techniques* (U.S. EPA 1998). Modifications to the planned scope were made in the field during the field activities. These modifications are documented in the *Draft Field Sampling Plan Alterations Report, Coeur d'Alene Basin RI/FS, Addendum 09, Delineation of Contaminant Source Areas in the Coeur d' Alene Basin using Survey and Hyperspectral Imaging Techniques* (U.S. EPA 1999).

4.2.3.9.3 Summary of Field Activities and Laboratory Analyses. The field activities conducted as part of FSPA No. 9 are summarized in this section. The field activities conducted as part of the field reconnaissance, aerial photogrammetry, and hyperspectral imaging (including XRF field measurement) are discussed in the following sections.

Field Reconnaissance. Field notes and photographs were taken during the reconnaissance and field sampling activities. The field reconnaissance notes and photographs were used by the field crews during the planning and execution of the field sampling activities. Selected photographs were scanned for future reference.

Aerial Photogrammetry. Ground surveys were conducted to set survey control for aerial photography indexing. The study areas were flown and aerial photographs were successfully obtained. Selected areas in Pine Creek, Ninemile Creek, and Canyon Creek were contour mapped. Photographic plates and copies were produced and indexed in hard copy (URSG/CH2M HILL 1998a) and an electronic version on CD (URSG/CH2M HILL 1999a).

X-Ray Fluorescence (XRF) Field Measurements. During August of 1998, a portable XRF was used to analyze multi-media samples in the field at selected locations in the Coeur d'Alene Basin. The purpose of this work was the ground truthing portion of the hyperspectral imaging survey conducted under this FSPA. A wide range of materials was tested, including soil, rock, tailings, forest litter, and various plants. Data for a total of 452 samples were loaded in the project database. These samples were obtained from 414 locations. Details of the field activities, chemical analysis results, and data analysis of the XRF data are included in Appendix D.

Other Work. Surface water samples were collected in August 1999 from two locations along Beaver Creek (BV-13 and BV-14). One environmental sample was collected from BV-13, and one environmental sample and one field duplicate were collected from BV-14. The surface water samples were analyzed for total and dissolved metals (CLP) by Columbia Analytical along with general water quality parameters (total dissolved solids [TDS], total suspended solids [TSS], alkalinity, hardness, and sulfates).

4.2.3.10 FSPA No. 11A

FSPA No. 11A focuses on re-sampling locations established during FSPA No. 8 in order to further evaluate chemical and physical characteristics of the study area. FSPA No. 11 was divided into FSPA Nos. 11A and 11B. FSPA No. 11B, stream sampling, during a spring snow melt was not conducted. The data will be used to help evaluate human health and ecological risks and to help evaluate remedial alternatives in the FS. The field work conducted under FSPA No. 11A consisted of collection and analysis of groundwater samples from the existing monitoring wells, and collection of surface water samples from Ninemile Creek, Canyon Creek and Pine Creek. In addition, hydrogeologic testing in the form of slug tests was performed at various existing monitoring wells. The purpose, scope, and summary of field activities and laboratory analyses are summarized below. Modifications to the previously published FSPA are provided in Appendix J.

4.2.3.10.1 Purpose. The purpose of FSPA No. 11A is to provide chemical and physical data from locations within the South Fork of the Coeur d'Alene River basin. The data will be used to help evaluate human health and ecological risks and to help evaluate remedial alternatives for a feasibility study (FS) to be published at a later date. Locations to be sampled or measured during the implementation of the plan have been sampled or measured at least once during the implementation of FSPA No. 8. Data collected from FSPA No.11A will be compared to previously collected data for evaluation during the RI/FS.

4.2.3.10.2 Scope. The scope of FSPA 11A was described in the *Field Sampling Plan for the Coeur d'Alene Basin-Wide RI/FS, Addendum 11A, Tier 2 Source Area Characterization Field Sampling Plan* (U.S. EPA 1999). The modifications are documented in the *Field Sampling Plan Alteration Report for the Coeur d'Alene Basin-Wide RI/FS, Addendum 11A, Tier 2 Source Area Characterization* (U.S. EPA 2000).

4.2.3.10.3 Summary of Field Activities and Laboratory Analyses. The field sampling activities are summarized in this section. A summary of the quantity of samples collected in December 1999 as part of FSPA No. 11A is provided in Table 4.2.3-18.

Task 1—Well Sampling. Forty-one wells were sampled. Eleven of the wells had samples collected from 2 depth intervals and 30 wells from one depth interval. Wells sampled were located in Canyon Creek, Ninemile Creek, and Pine Creek.

Task 2—Surface Water Sampling. Surface water flow measurements were obtained and water samples were collected at twenty-two locations near (in many cases adjacent to) the monitoring wells. Stream flow gauging and sampling were conducted in Canyon Creek, Ninemile Creek, and Pine Creek. A total of 24 samples was collected, of which 22 were environmental samples and 2 were field duplicates. Samples and flow measurement were taken as soon as possible after the corresponding monitoring well was sampled (in most cases less than 1 hour). For some locations that had multiple monitoring wells or wells with multiple sampling depths stream flow measurements were collected within 1 hour and 45 minutes. During sample collection, field parameters were measured, including pH, conductivity, temperature, dissolved oxygen, redox, and turbidity.

Task 3—Slug Testing. Rising-head slug tests and a falling-head slug tests were to be performed at 17 designated monitoring wells. However, because in 13 of the 17 wells the top of the screened interval was unsaturated, field personnel were unable to conduct falling head tests at these wells. If the top of the screened interval isn't saturated and the falling head test is performed it may lead to an overestimate of the conductivity of the formation. Only rising head tests were conducted at these 13 wells. Rising and falling head slug tests were performed at 4 MWs. Slug test data are included in Appendix F.

4.2.3.11 FSPA No. 12

The fieldwork conducted under FSPA No. 12 consisted of sampling and analysis of soils from yards, gardens, play areas, and gravel driveways. To assess groundwater exposure pathways, drinking water sampling was conducted on indoor taps for those residences that did not get water supplied from a community well or water district. The purpose of collecting soil and drinking water samples on a residential property was to gather data on metals concentrations. This information was used to evaluate the risk from direct exposure pathways to adults and children that are playing, gardening, conducting other outdoor activities, or using potentially contaminated groundwater for drinking and cooking. The results of this sampling activity were used to support the HHRA and to determine if early removal actions were warranted (U.S. EPA 1999a).

4.2.3.11.1 Purpose. The purpose of this sampling event was to identify soils at residential properties that may require an early removal action by the EPA. Drinking water analytical data were used to evaluate direct exposure pathways to residents via ingestion. In addition, soil analytical data were used to evaluate direct exposure pathways to residents while playing or working at their homes. Properties were identified for the sampling effort by residents who called the EPA and requested sampling to be performed at their homes in response to an advertisement placed in the local newspaper.

4.2.3.11.2 Scope. The scope of FSPA No. 12 was described in the *Field Sampling Plan and Quality Assurance Project Plan for the Bunker Hill Basin-Wide RI/FS, Addendum 12, Call in Residential Sampling to Support the Human Health Risk Assessment* (U.S. EPA 1999a). Modifications are documented in the *Field Sample Plan Alteration for the Residential Sampling to Support the Human Health Risk Assessment* (U.S. EPA 1999b).

4.2.3.11.2 Summary of Field Activities and Laboratory Analyses. The field sampling activities conducted in April and May 1999 are summarized in this section. Location information for this sampling event is confidential and, therefore not included in this report. A summary of the quantity of samples collected as part of FSPA No. 12 is provided in Table 4.2.3-19. Sample information is provided in Appendix A.

Task 1—Collection of Residential Soil Samples. Thirty-three properties were sampled for this field effort. A total of 820 soil samples was collected, of which 743 were environmental samples and 77 were field duplicates. The number of samples collected from the different areas are as follows: 1 sample from a play area, 14 samples from garden plots, 18 samples from gravel driveways, and 58 samples from downspouts and roof driplines. Soil samples were sieved through a #80-mesh sieve and only the portion that passed was analyzed for total metals.

Task 2—Collection of Drinking Water Samples. Drinking water was collected from a total of nine residences that had a private well, and four homes that were connected to a the same community well. A total of 30 samples was collected, of which 26 were environmental samples and 4 were field duplicates. Half of the samples were collected from a tap that had not been used for 6 hours and half of the samples were collected after the water had been allowed to run for at least 10 minutes.

Task 3—Identification of Other Potential Exposure Pathways. No other potential exposure pathways were observed in the field; therefore, no additional samples were collected.

4.2.3.12 FSPA No. 13

The field work conducted under FSPA No. 13 consisted of sampling and analysis of soil from several sites, including: school yards, day cares, and a common use area in the Coeur d'Alene River basin. The purpose, scope, and summary of field activities and laboratory analyses are summarized below. Modifications to the previously published FSPA are provided in Appendix J.

4.2.3.12.1 Purpose. The purpose of the FSPA No. 13 sampling event was to identify school/day care properties and a common use area with metal concentrations in soil that were sufficiently elevated to warrant a removal action. The data were to be used to help evaluate the risk from direct exposure pathways to adults and children that were playing on or using the properties.

4.2.3.12.2 Scope. The scope of FSPA No. 13 was described in the *Draft Field Sampling for the Bunker Hill Basin-Wide RI/FS, Addendum 13, School Yard/Daycare Sampling to Support the Human Health Risk Assessment/Removal Actions* (U.S. EPA 1999a). Modifications to the planned scope were made in the field during the sampling activities. These modifications are documented in the *Draft Field Sampling Plan Alterations, Coeur d'Alene Basin-Wide RI/FS, Shoshone County, Idaho, Addendum 13, School Yard/Daycare Sampling to Support the Human Health Risk Assessment/Removal Actions* (U.S. EPA 1999b).

4.2.3.12.3 Summary of Field Activities and Laboratory Analyses. A total of 14 sites were sampled in August and September 1999 during this field effort and a total of 451 samples were collected and analyzed of which 410 were environmental samples and 41 were field duplicates. A summary of the quantity of samples collected as part of the FSPA No. 13 sampling is provided in Table 4.2.3-20. Samples were analyzed for total metals (CLP) by Sentinel and SWRI. Site and location information and sample information is provided Appendix A. The sampling locations are shown on figures in the nature and extent section (Part 3, Section 4).

4.2.3.13 FSPA No. 15

The field work conducted under FSPA No. 15 consisted of sampling and analysis of sediment (beach sand) from common use areas (CUAs) along the Spokane River. The purpose, scope, and summary of field activities and laboratory analyses are summarized below. Modifications to the previously published FSPA are provided in Appendix J.

4.2.3.13.1 Purpose. The purpose of the FSPA No. 15 sampling event was to provide adequate data to verify whether the conclusion that areas presently assumed to pose no significant risk to human health may be eliminated from further investigation is in fact warranted. The data were also to be used to identify appropriate remedial measures at those areas found to be impacted.

4.2.3.13.2 Scope. The scope of FSPA No. 15 was described in the *Field Sampling for the Coeur d'Alene Basin-Wide RI/FS, Addendum 15, Spokane River - Washington State Common Use Area Sediment Characterization* (USEPA 1999a). Modifications to the planned scope were made in the field during the sampling activities. These modifications are documented in the *Draft Field Sampling Plan Alterations, Coeur d'Alene Basin-Wide RI/FS, Shoshone County, Idaho, Addendum 15, Spokane River - Washington State Common Use Area Sediment Characterization* (USEPA 1999b).

4.2.3.13.3 Summary of Field Activities and Laboratory Analyses. A total of 18 CUAs were sampled during this field effort and a total of 253 samples were collected and analyzed of which 224 were environmental samples and 29 were field duplicates. A summary of the quantity of samples collected as part of the FSPA No. 15 common use area sampling is provided in Table 4.2.3-21. Site and location information and sample information are provided in Appendix A. The sampling locations are shown on figures in the nature and extent section.

4.2.3.14 FSPA No. 16

The field work conducted under FSPA No. 16 consisted of sampling and analysis of soil at 55 residences and drinking water supplies at 15 residences. Properties to be sampled were identified by the residents or property owners who called and requested sampling of their property.

Additionally, soil samples were collected from the Mullan Football Field, a picnic area at the Babe Ruth Field, and the Little League Baseball Field.

4.2.3.14.1 Purpose. The purpose of collecting soil samples on a residential property was to gather data on metal concentration is surface and subsurface soils. The data were used to evaluate whether the yard soil around the home requires removal in order to protect health. The objective of the residential sampling was to identify residential yards for remedial action, if needed. Sampling of private water supplies was to provide data to evaluate the need for filters or hook-up to municipal systems for the residence. The purpose of the sampling of the Mullan Football Field was to determine if metal concentrations are sufficiently elevated to warrant a removal action.

4.2.3.14.2 Scope. The scope of FSPA No. 16 was described in the *Field Sampling for the Coeur d'Alene Basin-Wide RI/FS, Addendum 16, Spring 2000 Call-In Residential and Mullan Football Field Sampling* (USEPA 2000a). Modifications to the planned scope were made in the field during the sampling activities. These modifications are documented in the *Field Sampling Plan Alterations for the Coeur d'Alene Basin-Wide RI/FS, Field Sampling Plan No. 16, Spring 2000 Call-In Residential and Mullan Football Field Sampling* (USEPA 2000b).

4.2.3.14.3 Summary of Field Activities and Laboratory Analyses. The field work conducted under FSPA No. 16 consisted of sampling and analysis of soil at 55 residences and drinking water supplies at 15 residences. Properties to be sampled were identified by the residents or property owners who called and requested sampling of their property. Additionally, 102 soil samples were collected from the Mullan Football Field, a picnic area the Babe Ruth field, and the Little League Baseball Field. Samples were collected by URS Greiner and completed from March 20 through April 1, 2000. A summary of the quantity of samples collected as part of the FSPA No. 16 sampling is provided in Table 4.2.3-22. Soil samples were sieved prior to analysis.

4.2.3.15 FSPA No. 18

The field work conducted under FSPA No. 15 consisted of sampling and analysis of sediment (beach sand) from depositional areas and CUAs along the Spokane River. The purpose, scope, and summary of field activities and laboratory analyses are summarized below.

4.2.3.15.1 Purpose. FSPA No. 18 was part of the further evaluation of sediments along the Spokane River between the Idaho-Washington border and Upriver Dam, which was indicated as necessary by the findings of the screening-level risk assessment.

4.2.3.15.2 Scope. The scope of FSPA No. 18 was described in the *Final Field Sampling Plan for the Coeur d'Alene Basin-Wide RI/FS Addendum No. 18—Fall 2000 Field Screening of Sediment in Spokane River Depositional Areas* (USEPA 2000). Modifications to the planned scope were made in the field during the sampling activities. These modifications, and a summary of results, are documented in the *Final Field Sampling Plan Addendum No. 18, Fall 2000 Field Screening of Sediment in Spokane River Depositional Areas, Summary of Results, Coeur d'Alene Basin RI/FS, Revision 1* (USEPA 2001).

4.2.3.15.3 Summary of Field Activities and Laboratory Analyses. The field efforts performed by URSG under FSPA No. 18 consisted of three tasks:

Task 1—Coordinate with USGS and Ecology. Coordination of this field effort with the USGS and Ecology was required because the depositional areas along the Spokane River were originally identified by the USGS survey crew. The depositional areas sampled were a subset of the original depositional areas identified by USGS and Ecology that were prioritized by accessibility and public use. The URSG field crew met every day with the USGS and Ecology to identify the areas to be sampled.

Task 2—Collect Field Portable X-Ray Fluorescence (FPXRF) data. FPXRF analysis of field-sieved sediment samples was performed to provide data on arsenic, lead, and zinc concentrations in river sediments. These data were used to evaluate whether the depositional areas require additional investigation or assessment for removal actions.

Task 3—Submit confirmation samples. Collection of one laboratory confirmation sediment sample from each depositional area was performed to allow for comparison of lead and zinc FPXRF data to laboratory data.

A total of 25 sites were sampled during FSPA No. 18. This total includes 21 depositional areas, 4 bank profile sites, and 2 common use areas (CUAs). The CUAs, originally sampled during FSPA No. 15 (USEPA 1999), were sampled at the request of Ecology. The total of 25 sites includes 2 sites where both random and bank profile samples were collected. A total of 51 bulk samples were collected by USGS for field screening only. Sample location information is not available for the bulk screening samples. A total of 264 sediment samples were collected during FSPA No. 18. A summary of the quantity of samples collected as part of the FSPA No. 18 sampling is provided in Table 4.2.3-23.

4.2.3.16 USGS Sampling and Analysis Tasks

4.2.3.16.1 Task 1—Synoptic Sampling of a High-Flow Event on the Coeur d'Alene River System. The purpose of task 1 was to characterize surface-water concentrations and loads of cadmium, lead, and zinc on the ascending and descending limbs of the 1999 snowmelt-runoff in May 1999 to provide additional data on metals concentrations and loads during periods of high flow, and identify whether differences occurred on descending and ascending limbs. Surface-water samples were collected from nine monitoring stations in Canyon, Ninemile, and Pine Creeks, the South Fork, and the lower North Fork as discharge increased, peaked, and declined (Woods 2000a, USGS 1999a,f).

4.2.3.16.2 Task 2—Streamflow and Water-Quality Monitoring. The purpose of task 2 was to characterize surface-water concentrations and loads of cadmium, lead, zinc, nitrogen, and phosphorus on a daily basis over the 1999 water year to provide complete seasonal information on metals concentrations and loads throughout the Coeur d'Alene basin. Surface-water samples were collected periodically over the annual hydrograph at 29 monitoring stations on the Coeur d'Alene, St. Joe, St. Marie, and Spokane Rivers (Woods 2000b, USGS 1999 a,b,f).

4.2.3.16.3 Task 3—Limited Limnological Evaluations, Metal and Nutrient Remobilization From Sediments into the Water Column of Lake Coeur d'Alene:

- **Subtask A**—Metal and nutrient remobilization. The purposes of subtask A of task 3 were to quantify benthic fluxes of dissolved cadmium, lead, zinc, nitrogen, and phosphorus into Coeur d'Alene Lake for comparison to riverine-generated fluxes to the lake and to resolve whether lake sediment could be a significant source of metals and nutrients to the lake. Benthic fluxes were measured at two lake stations during August 1999 using benthic-flux chamber deployments and laboratory core incubations (Kuwabara et al 2000, USGS 1999f).

- **Subtask B**—Limnological evaluations. The purposes of subtask B of task 3 were to evaluate concentrations of nutrients, chlorophyll, trace elements, and dissolved oxygen to assess long term trends in important limnological characteristics and to determine if conditions in Coeur d'Alene Lake had changed since previous studies. The majority of the assessment was based on monthly samples collected at three lake stations between early June and mid-October 1999. Near the peak of snowmelt runoff (early June), eight lake stations were sampled to characterize the in-lake movement of the inflow plumes of the Coeur d'Alene and St. Joe Rivers (RI Part 5, USGS 1999a,f).

4.2.3.16.4 Task 4—Downstream Dispersion of Sediment-Associated Trace Elements From Lake Coeur d'Alene. The purpose of task 4 was to assess the extent and magnitude of trace-element contamination of the Spokane River downstream of Coeur d'Alene Lake to better define the nature and extent of metals contamination along the Spokane River. Numerous surficial sediment samples were collected between the outlet of Coeur d'Alene Lake and the Spokane River outlet arm of Lake Roosevelt. Sediment cores were collected in several impoundments in order to determine depositional history of trace elements (Grosbois et al 2000, USGS 1999a,f).

4.2.3.16.5 Task 5—Variation in Heavy Metal Speciation of Soils and Sediments Within the Lower Coeur d'Alene River Basin. The purposes of task 5 were to evaluate potential geochemical problems associated with disturbance of floodplain materials during remedial activities and to resolve uncertainties regarding the possible effects of geochemical conditions or the selection of remedies for the lower Coeur d'Alene River floodplain. Empirical pore-water geochemical data were collected from *in situ* floodplain materials and then subsequently from those same materials after they were disturbed and oxygenated (Balistrieri et al 2000, USGS 1999a,f).

4.2.3.16.6 Task 6—Surficial Geologic Map of Tailings Contaminated Soils and Sediment in the Valley of the South Fork Coeur d'Alene River. The purpose of task 6 was to develop maps of the distribution of tailings-contaminated materials to assist the RI/FS process in identification of potential source areas of dissolved metals (Box 2000, USGS 1999a,f).

4.2.3.16.7 Task 7—Evaluation of Suspended and Bedload Sediment Transport Within the Coeur d'Alene River Basin and Affected Areas:

- **Subtask A**—Evaluate trace-element transport. The purposes of subtask A of task 7 were to characterize surface-water concentrations and loads of cadmium, lead, and zinc within the mainstem Coeur d'Alene River under the hydrologic conditions of rising, steady, and falling water-surface elevations and define the dynamic processes affecting metals release and transport under various flow conditions. Surface-water samples were collected at seven monitoring stations during March, June, September, and October 1999. The samples were analyzed for whole-water recoverable, filtered, and dissolved concentrations to assess the partitioning of trace elements among particulate, colloidal, and dissolved fractions (Woods 2000c, USGS 1999a,f).

- **Subtask B**—Evaluate suspended- and bedload-sediment transport. The purpose of subtask B of task 7 was to develop transport curves for suspended and bedload sediment in order to improve the understanding of the effects of different discharge levels on sediment transport. During the 1999 and 2000 water years, eight monitoring stations were sampled for suspended and bedload sediment concentrations during hydrologic events of low, moderate, and high discharge as well as during baseflow conditions (Clark and Woods 2000, USGS 1999a,f).

4.2.3.16.8 Task 8—Technical Assistance. The purpose of task 8 was to provide USGS expertise to EPA and its consulting team in the interpretation of hydrologic and water-quality data used to develop the RI and FS reports to facilitate EPA's understanding of work completed previously and in progress (USGS 1999a,c,f).

4.2.3.16.9 Task 9—Groundwater Seepage and Contribution of Metal Loading in the South Fork Coeur d'Alene River Valley. The purposes of task 9 were to characterize the concentrations and loads of dissolved trace elements exchanged between surface water and groundwater within the South Fork and to develop a better understanding of the mechanisms and magnitude of loading of metals to streams from groundwater discharge. Numerous monitoring stations were sampled synoptically and in triplicate during three assessment periods (June, September, and October 1999). The monitoring stations were situated in three areas: Woodland Park on Canyon Creek, Osburn Flats on the South Fork, and Smelterville Flats on the South Fork (Barton 2000, USGS 1999e).

4.2.3.16.10 Task 10—Spring 1999 Snowmelt-Runoff Synoptic Sampling of Coeur d'Alene River Basin. The purpose of task 10 was to characterize surface-water concentrations and loads of cadmium, lead, and zinc near the peak of the 1999 snowmelt runoff in May 1999 to provide additional data on concentrations of metals during periods of high flow. Surface-water samples were collected from 42 monitoring stations within the South Fork, North Fork, and mainstem Coeur d'Alene and their tributaries as discharge peaked (Woods 2000d, USGS 1999d,f).

4.2.4 Data Quality Assessment

The DQA Process is a comparison of the implemented sampling approach and resulting analytical data against the sampling and data quality requirements specified by the DQOs. Results of the DQA are used to determine whether data are of adequate quality and quantity to support the decisionmaking process. The data quality assessment performed for this study includes evaluation of the quality of the analytical data generated for each of the field sampling efforts and evaluation of the adequacy of the data set in meeting the intended data uses.

4.2.4.1 Laboratory Data Quality/Data Validation

To provide a high level of quality for the analytical data collected during this study, samples were submitted to commercial laboratories for analysis using the USEPA's contract laboratory program (CLP) methods or at non-CLP laboratories using USEPA SW-846 methods. High quality is maintained in both of these programs through the use of on-site audits, performance evaluation samples, quarterly performance reports, fraud detection mechanisms, performance based scheduling, and continuous inspection of laboratory data.

Additionally, all analytical data were validated according to the USEPA's data validation guidance (USEPA 1994). Following data validation, the data set was further reviewed for proper application of data qualifiers. Data identified during validation as being unacceptable for project uses were not carried forward in the remedial investigation.

4.2.4.2 Data Usability

The data usability evaluation is a comparison of the implemented sampling approach and resulting analytical data against the sampling and data quality requirements specified in each field sampling and analysis plan. The purpose of each data collection effort was to investigate impacted areas or areas potentially impacted by mining-related activities and determine if observed metals concentrations were greater than applicable screening levels. If concentrations are less than screening levels, the area is considered not impacted. If concentrations are greater than screening levels, the area is considered impacted. The purpose of the remedial investigation study was to evaluate available information and determine which areas, or media (e.g., soil, sediment, groundwater, surface water), are impacted by mining-related activities. For areas or media that are considered impacted, the information is carried through and evaluated further in the risk assessments and feasibility study.

The sampling plans were designed to provide data to decide if areas are impacted with a high degree of certainty. Since data can only estimate what the true condition of an area is, decisions that are based on measurement data could be in error. Risk assessment requires a high degree of certainty in the supporting data (USEPA 1992); therefore, field sampling and analysis plans developed to collect data specifically to support the human health risk assessment (residential and common use area soil samples) included sample collection designs with a known confidence level (95 or 99 percent). All other data were collected judgmentally; therefore, the degree of certainty associated with these data sets cannot be evaluated. The degree of certainty associated with the sample types identified in Table 4.2.2-1 are discussed in this section.

4.2.4.2.1 Source Areas. The Bureau of Land Management (BLM) identified approximately 1,080 mining-related source areas in the basin. Within these source areas, five different primary source types were identified: mine workings, waste rock, tailings, concentrates and other process wastes, and artificial fill. Secondary sources include affected media (e.g., groundwater, floodplain deposits, bottom sediments) that act as sources of metals to other media or receptors. Of approximately 1,080 identified source areas, samples were collected from approximately 160. Less than 5 samples were collected from the majority of these source areas; therefore, data are not available to directly evaluate most of the source areas.

Statistically based sampling was not used to collect samples from source areas. Because available historical source area data indicated that metals concentrations were much greater than screening levels, a less rigorous sampling design was implemented to collect data for the remedial investigation as confirmation of historical results. To illustrate this point, available source type data are compared to screening levels in Table 4.2.4-1. Averages, coefficients of variation and probability that the average concentration is above screening levels are shown.

Probabilities are estimated assuming that concentrations are lognormally distributed. Sample statistics are based on pooled samples from all individual sources comprising each source type. It is conservatively assumed that the variability in the pooled sample is equal to the variability in the average (or mean) concentration of (or between) individual source areas comprising the given source type. Therefore, the estimated probabilities are expected to underestimate the chance that any given individual source area will have an average or mean concentration that exceeds the screening level.

Though not all adits, waste rock piles, and tailings ponds were sampled and analyzed, similar mining-related processes produced these same source types throughout the basin. It is therefore reasonable to assume that if measured adit, waste rock, and tailings metals concentrations exceeded screening levels (including background concentrations), then metals concentrations in source areas of these same types (but were not sampled) would also exceed screening levels.

4.2.4.2.2 Groundwater. A limited number of samples were collected from groundwater in the upper portion of the basin. For the remedial investigation, monitoring wells were installed and sampled in Canyon Creek, Ninemile Creek, and Pine Creek to evaluate groundwater metals concentrations associated with nearby source areas and the losing and gaining interaction with surface water. An attempt was not made to fully characterize groundwater conditions in these areas.

4.2.4.2.3 Surface Water. The largest set of available data for the remedial investigation was for surface water. Data from numerous studies conducted since 1991 were combined for evaluation in the RI. Because surface water is a dynamic medium and metals concentrations are influenced by numerous factors (e.g., rainfall, snowfall, temperature, discharge, groundwater inflow, sediment mobilization, geochemical conditions), statistically-based sampling designs were not used to guide surface water collection efforts. However, to evaluate surface water metals concentrations relative to screening levels and account for the variability/uncertainty in data for discrete surface water samples, statistical analyses of the available data were used with a probabilistic model to estimate surface water discharge, metal concentrations and metal mass loading. The model was developed to provide practical tools to deal with the complexity and uncertainty in available information. The model's purpose is to aid understanding, communication, and decision making and can be used for estimating both pre-remediation and post-remediation conditions. Specifically, the model aims to provide, for a given metal, quantitative estimates of:

1. The probability that the true chemical concentration or mass loading will not (or will) exceed a given level, including a performance or remediation standard or goal

2. The value of a chemical concentration or mass loading having a given probability of non-exceedance (or exceedance)

3. The value of chemical concentration or mass loading needed to meet a given remediation or performance goal with specified probability

The model is described in detail in Section 5.4, Fate and Transport Evaluation.

4.2.4.2.4 Residential, Upland Common Use Area, School, and Daycare Samples. For soil samples collected specifically to support the human health risk assessment, the number of samples collected for each study area (e.g., school yards, beaches) was determined using a method that permits estimation of the median concentration with a pre-specified level of confidence (Conover 1980). For these sampling efforts (FSPAs 5, 6, 7, 12, 13, 15, and 16), a confidence level of either 95 or 99 percent was selected and the appropriate number of samples determined as detailed in the FSPAs. The sampling scheme that was used in each of the specific study areas was either random or systematic. Metals data generated in this manner were used in the human health risk assessments to calculate exposure point concentrations and evaluate risk.

Garden produce samples were collected judgmentally. Tap water (drinking water) samples were collected from each residence. Indoor dust samples were collected from floor mats and vacuum cleaner bags. Paint chip samples were only collected from residences with observed chipping or pealing paint.

Table 4.1-1
Historical Data Sources

Source	Reference	Matrix	Collection Dates
USGS	USGS 2000a	Sediment	1993-1998
USGS	USGS 1992	Surface Sediment	August 1989, 1991
USGS	USGS 1999, 2000b, 2000c	Surface Water	October 1998 - October 1999
USFS	USFS 1995	Surface Water	January 1993 - August 1993
CCJM	Mackey and Yarbrough 1995	Groundwater	July 1994
CCJM	Mackey and Yarbrough 1995	Surface Soil	January 1993 - July 1994
CCJM	Mackey and Yarbrough 1995	Subsurface Soil	January 1993 - July 1994
CCJM	Mackey and Yarbrough 1995	Surface Water	July 1994 - November 1994
CCJM	Mackey and Yarbrough 1995	Sediment	July 1994
IDEQ	Idaho Department of Environmental Quality - 1998a, 1998b	Surface Water	October 1993 - February 1999
MFG	McCulley, Frick & Gilman, 1998	Groundwater	April 1993 - October 1997
MFG	MFG 1997	Surface and subsurface soil	1994
MFG	McCulley, Frick & Gilman, 1991 and 1992.	Surface Water	May 1991 - October 1991
U.S. EPA Region 10	EPA 1998b	Groundwater	October 1996 - February 1998
U.S. EPA Region 10	EPA 1998b	Surface Water	February 1997 - February 1998
U.S. EPA Region 10	U.S. EPA 1998a, 1998c, 1998d	Surface Water	January 1994 - June 1998
USGS	EPA 1999	Sediment	February 1999
IGS	Idaho Geological Survey, 1999a,b,c,d	Surface Soil	January 1997
IGS	Idaho Geological Survey, 1999a,b,c,d	Surface Water	January 1997

Table 4.1-1 (Continued)
Historical Data Sources

Source	Reference	Matrix	Collection Dates
University of Idaho	Hoffman, 1995; Rabbi,1994	Sediment	1991 to 1992

Table 4.2.2-1
FSPA Sampling Design Summary

FSPA	Sample Type	Sampling Design	Purpose	Data Use
1	Sediment cores	Transects	Vertical distribution of metals	RI, EcoRA, FS
2	Adit, seep and creek surface water	Grab	Source area metals characterization	RI, EcoRA, HHRA, FS
3	Sediments	Transects	Vertical distribution of metals	RI, EcoRA, HHRA, FS
4	Adit, seep and creek surface water – high-flow event	Grab	Source area metals characterization	RI, EcoRA, HHRA, FS
5	Common Use Area (CUA) soil/sediment	Random sampling	Metals characterization and development of exposure point concentrations	RI, EcoRA, HHRA, FS
	Disturbed surface water	Random sampling	Development of exposure point concentrations	HHRA, FS
	Local well drinking water	Grab	Characterize public drinking water supplies in CUAs	HHRA, FS
6	Residential outdoor soil (yards)	Systematic sampling	Development of exposure point concentrations	HHRA, FS
	Residential outdoor soil (high-biased)	Grab	Characterization of potentially high concentration areas	FS
	Garden produce	Grab	Confirmation of existing modeled and measured data	HHRA, FS
	Residential drinking water	Grab	Comparison to immediate action screening levels and development of exposure point concentrations	HHRA, FS
	Indoor dust	Grab	Development of exposure point concentrations	HHRA, FS
	Vacuum cleaner bags	Grab	Development of exposure point concentrations	HHRA, FS
	Lead-based paint	Grab	Determine presence	FS
7	Residential outdoor soil (yards)	Systematic sampling	Development of exposure point concentrations	HHRA, FS
8	Subsurface soil borings	Grab	Source area metals characterization	RI, FS
	Surface soil	Grab	Source area metals characterization	RI, EcoRA, HHRA, FS
	Groundwater	Grab	Source area metals characterization	RI, FS
	Surface water	Grab	Source area metals characterization	RI, EcoRA, FS
9	Surface materials	Grab	Calibration of hyperspectral imaging, extent of metals concentrations	RI, EcoRA, FS

Table 4.2.2-1 (Continued)
FSPA Sampling Design Summary

FSPA	Sample Type	Sampling Design	Purpose	Data Use
11A	Groundwater	Grab	Source area metals characterization	RI, FS
	Surface water	Grab	Source area metals characterization	RI, EcoRA, FS
12	Residential outdoor soil (yards)	Systematic sampling	Development of exposure point concentrations	HHRA, FS
	Residential outdoor soil (high-biased)	Grab	Characterization of potentially high concentration areas	FS
	Residential drinking water	Grab	Comparison to immediate action screening levels and development of exposure point concentrations	HHRA, FS
13	School yard/daycare center soils	Random sampling	Development of exposure point concentrations	HHRA, FS
	School/daycare center drinking water	Grab	Comparison to immediate action screening levels and development of exposure point concentrations	HHRA, FS
15	CUA Sediment	Random and systematic sampling	Development of exposure point concentrations	RI, EcoRA, HHRA, FS
16	Residential outdoor soil (yards)	Systematic sampling	Development of exposure point concentrations	HHRA, FS
	Residential outdoor soil (high-biased)	Grab	Characterization of potentially high concentration areas	FS
	Residential drinking water	Grab	Comparison to immediate action screening levels and development of exposure point concentrations	HHRA, FS
	Football field and park soils	Systematic sampling	Development of exposure point concentrations	HHRA, FS
18	CUA and Depositional Area Sediment	Random and vertical profile	Development of exposure point concentrations	HHRA, FS

Notes:
EcoRA - ecological risk assessment
FS - feasibility study
FSPA - field sampling plan addenda
HHRA - human health risk assessment
RI - remedial investigation

Table 4.2.3-1
FSPA Sample Collection and Analysis Summary—Chemicals

FSPA	Laboratory	Matrix	Collection Date		Total Metals	Dissolved Metals
			First Sample	Last Sample		
FSPA No. 1	CHEMTECH	SD	11/12/1997	12/20/1997	275	
FSPA Nos. 1, 3	ARI	SD	11/12/1997	01/17/1998		
FSPA Nos. 1, 3	SWRI	SD	11/12/1997	01/17/1998		
FSPA No. 2	LAUCKS	SW	11/04/1997	01/16/1998	168	9
FSPA No. 2	MEL	SW	11/04/1997	11/20/1997		159
FSPA No. 3	SENTINEL	SD	12/11/1997	01/17/1998	129	
FSPA No. 4	CAS	SW	05/05/1998	05/17/1998	82	82
FSPA No. 4	SOUND	SW	05/07/1998	05/19/1998	64	64
FSPA No. 4	SVL	SB	05/19/1998	05/19/1998	15	
FSPA No. 4	SVL	SD	05/19/1998	05/19/1998	1	
FSPA No. 4	SVL	SS	05/19/1998	05/19/1998	8	
FSPA No. 4	SWRI	SW	05/06/1998	05/18/1998	80	80
FSPA No. 5	CHEMTECH	SB	08/18/1998	09/11/1998	367	
FSPA No. 5	CHEMTECH	SD	07/30/1998	09/10/1998	314	
FSPA No. 5	CHEMTECH	SS	07/29/1998	09/11/1998	260	
FSPA No. 5	LAUCKS	RW	08/03/1998	09/10/1998	113	
FSPA No. 5	SENTINEL	SB	08/18/1998	09/12/1998	299	
FSPA No. 5	SENTINEL	SD	07/31/1998	09/13/1998	226	
FSPA No. 5	SENTINEL	SS	07/31/1998	09/12/1998	227	
FSPA No. 5	SWRI	RW	07/30/1998	09/02/1998	174	
FSPA No. 5	SWRI	WR	07/29/1998	08/13/1998	4	
FSPA No. 6	CHEMTECH	SB	09/22/1998	10/29/1998	979	
FSPA No. 6	CHEMTECH	SD	10/07/1998	10/07/1998	1	
FSPA No. 6	CHEMTECH	SS	09/22/1998	10/29/1998	426	
FSPA No. 6	COLUMBWA	DF	09/22/1998	11/01/1998	126	
FSPA No. 6	COLUMBWA	PR	09/24/1998	10/21/1998	15	
FSPA No. 6	COLUMBWA	TI	09/23/1998	10/21/1998	35	
FSPA No. 6	LAUCKS	WR	09/22/1998	10/23/1998	177	
FSPA No. 6	SENTINEL	SB	09/22/1998	10/28/1998	762	
FSPA No. 6	SENTINEL	SD	10/16/1998	10/24/1998	4	
FSPA No. 6	SENTINEL	SS	09/22/1998	10/28/1998	368	
FSPA No. 7	SVL	SB	07/16/1998	08/01/1998	86	
FSPA No. 7	SVL	SS	07/16/1998	08/01/1998	30	
FSPA No. 7	SWRI	SB	07/23/1998	07/30/1998	67	
FSPA No. 7	SWRI	SS	07/23/1998	07/30/1998	23	
FSPA No. 8	ARI	SB	10/23/1998	11/09/1998	37	

Table 4.2.3-1 (Continued)
FSPA Sample Collection and Analysis Summary—Chemicals

FSPA	Laboratory	Matrix	Collection Date		Total Metals	Dissolved Metals
			First Sample	Last Sample		
FSPA No. 8	ARI	SS	11/10/1998	11/10/1998	17	
FSPA No. 8	INCHCAPE	SB	10/27/1998	11/18/1998	40	
FSPA No. 8	INCHCAPE	SS	10/25/1998	11/10/1998	22	
FSPA No. 8	LAUCKS	GW	12/03/1998	12/08/1998	52	52
FSPA No. 8	LAUCKS	SB	10/23/1998	11/18/1998		
FSPA No. 8	LAUCKS	SS	10/25/1998	12/21/1998		
FSPA No. 8	LAUCKS	SW	11/12/1998	12/07/1998	25	25
FSPA No. 8	SWOK	SS	12/21/1998	12/21/1998	5	
FSPA No. 8	SWRI	GW	12/01/1998	12/09/1998	65	62
FSPA No. 8	SWRI	SW	11/11/1998	12/09/1998	71	50
FSPA No. 9	CAS	SW	08/17/1999	08/17/1999	2	2
FSPA No. 9	Field XRF	DR	10/02/1998	10/06/1998	7	
FSPA No. 9	Field XRF	FI	10/13/1998	10/13/1998	4	
FSPA No. 9	Field XRF	FL	10/03/1998	10/05/1998	25	
FSPA No. 9	Field XRF	PL	10/03/1998	10/12/1998	139	
FSPA No. 9	Field XRF	RK	10/02/1998	10/13/1998	103	
FSPA No. 9	Field XRF	SD	10/12/1998	10/12/1998	5	
FSPA No. 9	Field XRF	SL	10/02/1998	10/13/1998	161	
FSPA No. 9	Field XRF	SU	10/13/1998	10/13/1998	1	
FSPA No. 11A	MEL	GW	11/30/1999	12/06/1999		
FSPA No. 11A	MEL	SW	12/01/1999	12/06/1999		
FSPA No. 11A	SWRI	GW	11/30/1999	12/06/1999	52	52
FSPA No. 11A	SWRI	SW	12/01/1999	12/06/1999	22	22
FSPA No. 12	SENTINEL	SB	04/30/1999	05/18/1999	697	
FSPA No. 12	SENTINEL	SS	04/30/1999	05/18/1999	322	
FSPA No. 12	SWRI	WR	05/03/1999	05/15/1999	104	
FSPA No. 13	CHEMTECH	SB	08/24/1999	09/14/1999	222	
FSPA No. 13	CHEMTECH	SS	08/24/1999	09/14/1999	95	
FSPA No. 13	SENTINEL	SB	08/25/1999	08/28/1999	235	
FSPA No. 13	SENTINEL	SS	08/25/1999	08/28/1999	89	
FSPA No. 15	CHEMTECH	SB	09/01/1999	09/10/1999	98	
FSPA No. 15	HONG WEST	SB	09/01/1999	09/09/1999		
FSPA No. 15	SENTINEL	SB	09/01/1999	09/09/1999	76	
FSPA No. 15	SOIL TECH	SB	09/01/1999	09/03/1999		
FSPA No. 16	AATS	SB	03/30/2000	03/30/2000	16	
FSPA No. 16	AATS	SS	03/30/2000	03/30/2000	5	

Table 4.2.3-1 (Continued)
FSPA Sample Collection and Analysis Summary—Chemicals

FSPA	Laboratory	Matrix	Collection Date		Total Metals	Dissolved Metals
			First Sample	Last Sample		
FSPA No. 16	CHEMTECH	SB	03/27/2000	03/27/2000	6	
FSPA No. 16	CHEMTECH	SS	03/23/2000	03/31/2000	74	
FSPA No. 16	MEL	WR	03/23/2000	03/30/2000	30	
FSPA No. 16	OTHER	SB	03/30/2000	03/30/2000	2	
FSPA No. 16	OTHER	SS	03/29/2000	03/31/2000	27	
FSPA No. 16	SENTINEL	SL	03/21/2000	03/23/2000	12	
FSPA No. 16	SENTINEL	SB	03/21/2000	03/30/2000	105	
FSPA No. 16	SENTINEL	SS	03/21/2000	03/31/2000	173	
FSPA No. 18	FIELD XRF	SD	8/24/2000	09/01/2000	264	
FSPA No. 18	CHEMTECH	SD	8/24/2000	09/01/2000	30	

Notes:
DF - Dust
DR - Debris/rubble
FI - Filter material
FL - Forest litter
FSPA - field sampling plan addendum
GW - Groundwater
PL - Plant
PR - Product
RK - Rock/cobbles/gravel
RW - Disturbed water
SB - Soil Boring
SD - Sediment
SL - Soil
SS - Surface Soil
SU - Sludge
SW - Surface Water
TI - Tissue
WR - Water

Table 4.2.3-2
FSPA Sample Collection and Analysis Summary—Water Quality

FSPA	Laboratory	Matrix	Collection Date		Hardness	Alkalinity	TDS	TSS	TS	Inorganic Ions	Nitrate-Nitrite	Sulfate	Sulfide	pH
			First Sample	Last Sample										
FSPA No. 1	CHEMTECH	SD	11/12/1997	12/20/1997										
FSPA Nos. 1, 3	ARI	SD	11/12/1997	01/17/1998					403			42	61	
FSPA Nos. 1, 3	SWRI	SD	11/12/1997	01/17/1998										
FSPA No. 2	LAUCKS	SW	11/04/1997	01/16/1998		9	9	9		9				
FSPA No. 2	MEL	SW	11/04/1997	11/20/1997		157	159	159				156		
FSPA No. 3	SENTINEL	SD	12/11/1997	01/17/1998										
FSPA No. 4	CAS	SW	05/05/1998	05/17/1998		82	82	82		57				
FSPA No. 4	SOUND	SW	05/07/1998	05/19/1998		63	64	64		64				
FSPA No. 4	SVL	SB	05/19/1998	05/19/1998										
FSPA No. 4	SVL	SD	05/19/1998	05/19/1998										
FSPA No. 4	SVL	SS	05/19/1998	05/19/1998										
FSPA No. 4	SWRI	SW	05/06/1998	05/18/1998		77	70	79		79				
FSPA No. 5	CHEMTECH	SB	08/18/1998	09/11/1998										
FSPA No. 5	CHEMTECH	SD	07/30/1998	09/10/1998										
FSPA No. 5	CHEMTECH	SS	07/29/1998	09/11/1998										
FSPA No. 5	LAUCKS	RW	08/03/1998	09/10/1998										
FSPA No. 5	SENTINEL	SB	08/18/1998	09/12/1998										
FSPA No. 5	SENTINEL	SD	07/31/1998	09/13/1998										
FSPA No. 5	SENTINEL	SS	07/31/1998	09/12/1998										
FSPA No. 5	SWRI	RW	07/30/1998	09/02/1998										
FSPA No. 5	SWRI	WR	07/29/1998	08/13/1998										
FSPA No. 6	CHEMTECH	SB	09/22/1998	10/29/1998										
FSPA No. 6	CHEMTECH	SD	10/07/1998	10/07/1998										
FSPA No. 6	CHEMTECH	SS	09/22/1998	10/29/1998										
FSPA No. 6	COLUMBWA	DF	09/22/1998	11/01/1998										
FSPA No. 6	COLUMBWA	PR	09/24/1998	10/21/1998										

Table 4.2.3-2 (Continued)
FSPA Sample Collection and Analysis Summary—Water Quality

FSPA	Laboratory	Matrix	Collection Date		Hardness	Alkalinity	TDS	TSS	TS	Inorganic Ions	Nitrate-Nitrite	Sulfate	Sulfide	pH
			First Sample	Last Sample										
FSPA No. 6	COLUMBWA	TI	09/23/1998	10/21/1998					13					
FSPA No. 6	LAUCKS	WR	09/22/1998	10/23/1998										
FSPA No. 6	SENTINEL	SB	09/22/1998	10/28/1998										
FSPA No. 6	SENTINEL	SD	10/16/1998	10/24/1998										
FSPA No. 6	SENTINEL	SS	09/22/1998	10/28/1998										
FSPA No. 7	SVL	SB	07/16/1998	08/01/1998										
FSPA No. 7	SVL	SS	07/16/1998	08/01/1998										
FSPA No. 7	SWRI	SB	07/23/1998	07/30/1998										
FSPA No. 7	SWRI	SS	07/23/1998	07/30/1998										
FSPA No. 8	ARI	SB	10/23/1998	11/09/1998										
FSPA No. 8	ARI	SS	11/10/1998	11/10/1998										
FSPA No. 8	INCHVT	SB	10/27/1998	11/18/1998										
FSPA No. 8	INCHVT	SS	10/25/1998	11/10/1998										
FSPA No. 8	LAUCKS	GW	12/03/1998	12/08/1998			52	53		51			52	
FSPA No. 8	LAUCKS	SB	10/23/1998	11/18/1998						46				76
FSPA No. 8	LAUCKS	SS	10/25/1998	12/21/1998						34				44
FSPA No. 8	LAUCKS	SW	11/12/1998	12/07/1998			25	25		25			25	
FSPA No. 8	SWOK	SS	12/21/1998	12/21/1998										
FSPA No. 8	SWRI	GW	12/01/1998	12/09/1998			32	32		32			32	
FSPA No. 8	SWRI	SW	11/11/1998	12/09/1998			47	47		47			47	
FSPA No. 9	CAS	SW	08/17/1999	08/17/1999										
FSPA No. 9	Field XRF	DR	10/02/1998	10/06/1998										
FSPA No. 9	Field XRF	FI	10/13/1998	10/13/1998										
FSPA No. 9	Field XRF	FL	10/03/1998	10/05/1998										
FSPA No. 9	Field XRF	PL	10/03/1998	10/12/1998										
FSPA No. 9	Field XRF	RK	10/02/1998	10/13/1998										

Table 4.2.3-2 (Continued)
FSPA Sample Collection and Analysis Summary—Water Quality

FSPA	Laboratory	Matrix	Collection Date		Hardness	Alkalinity	TDS	TSS	TS	Inorganic Ions	Nitrate-Nitrite	Sulfate	Sulfide	pH
			First Sample	Last Sample										
FSPA No. 9	Field XRF	SD	10/12/1998	10/12/1998										
FSPA No. 9	Field XRF	SL	10/02/1998	10/13/1998										
FSPA No. 9	Field XRF	SU	10/13/1998	10/13/1998										
FSPA No. 11A	MEL	GW	11/30/1999	12/06/1999	52	52	52	52		52	52			
FSPA No. 11A	MEL	SW	12/01/1999	12/06/1999	22	22	22	22		22	22			
FSPA No. 11A	SWRI	GW	11/30/1999	12/06/1999									52	
FSPA No. 11A	SWRI	SW	12/01/1999	12/06/1999									22	
FSPA No. 12	SENTINEL	SB	04/30/1999	05/18/1999										
FSPA No. 12	SENTINEL	SS	04/30/1999	05/18/1999										
FSPA No. 12	SWRI	WR	05/03/1999	05/15/1999										
FSPA No. 13	CHEMTECH	SB	08/24/1999	09/14/1999										
FSPA No. 13	CHEMTECH	SS	08/24/1999	09/14/1999										
FSPA No. 13	SENTINEL	SB	08/25/1999	08/28/1999										
FSPA No. 13	SENTINEL	SS	08/25/1999	08/28/1999										
FSPA No. 15	CHEMTECH	SB	09/01/1999	09/10/1999										
FSPA No. 15	HONG WEST	SB	09/01/1999	09/09/1999										
FSPA No. 15	SENTINEL	SB	09/01/1999	09/09/1999										
FSPA No. 15	SOIL TECH	SB	09/01/1999	09/03/1999										
FSPA No. 16	AATS	SB	03/30/2000	03/30/2000										
FSPA No. 16	AATS	SS	03/30/2000	03/30/2000										
FSPA No. 16	CHEMTECH	SB	03/27/2000	03/27/2000										
FSPA No. 16	CHEMTECH	SS	03/23/2000	03/31/2000										
FSPA No. 16	MEL	WR	03/23/2000	03/30/2000										
FSPA No. 16	OTHER	SB	03/30/2000	03/30/2000										
FSPA No. 16	OTHER	SS	03/29/2000	03/31/2000										
FSPA No. 16	SENTINEL	SL	03/21/2000	03/23/2000										

Table 4.2.3-2 (Continued)
FSPA Sample Collection and Analysis Summary—Water Quality

FSPA	Laboratory	Matrix	Collection Date		Hardness	Alkalinity	TDS	TSS	TS	Inorganic Ions	Nitrate-Nitrite	Sulfate	Sulfide	pH
			First Sample	Last Sample										
FSPA No. 16	SENTINEL	SB	03/21/2000	03/30/2000										
FSPA No. 16	SENTINEL	SS	03/21/2000	03/31/2000										

Notes:
DF - Dust
DR - Debris/rubble
FI - Filter material
FL - Forest litter
FSPA - field sampling plan addendum
GW - Groundwater
PL - Plant
PR - Product
RK - Rock/cobbles/gravel
RW - Disturbed water
SB - Soil Boring
SD - Sediment
SL - Soil
SS - Surface Soil
SU - Sludge
SW - Surface Water
TDS - Total dissolved solids
TI - Tissue
TS - Total solids
TSS - Total suspended solids
WR - Water

Table 4.2.3-3
FSPA Sample Collection and Analysis Summary—Soil Parameters

FSPA	Lab	Matrix	Collection Date		TOC	ABA	AVS/ SEM	Grain-size	Specific Gravity
			First Sample	Last Sample					
FSPA No. 1	CHEMTECH	SD	11/12/1997	12/20/1997					
FSPA Nos. 1, 3	ARI	SD	11/12/1997	01/17/1998	384		63		
FSPA Nos. 1, 3	SWRI	SD	11/12/1997	01/17/1998				396	396
FSPA No. 2	LAUCKS	SW	11/04/1997	01/16/1998					
FSPA No. 2	MEL	SW	11/04/1997	11/20/1997					
FSPA No. 3	SENTINEL	SD	12/11/1997	01/17/1998					
FSPA No. 4	CAS	SW	05/05/1998	05/17/1998					
FSPA No. 4	SOUND	SW	05/07/1998	05/19/1998					
FSPA No. 4	SVL	SB	05/19/1998	05/19/1998					
FSPA No. 4	SVL	SD	05/19/1998	05/19/1998					
FSPA No. 4	SVL	SS	05/19/1998	05/19/1998					
FSPA No. 4	SWRI	SW	05/06/1998	05/18/1998					
FSPA No. 5	CHEMTECH	SB	08/18/1998	09/11/1998					
FSPA No. 5	CHEMTECH	SD	07/30/1998	09/10/1998					
FSPA No. 5	CHEMTECH	SS	07/29/1998	09/11/1998					
FSPA No. 5	LAUCKS	RW	08/03/1998	09/10/1998					
FSPA No. 5	SENTINEL	SB	08/18/1998	09/12/1998					
FSPA No. 5	SENTINEL	SD	07/31/1998	09/13/1998					
FSPA No. 5	SENTINEL	SS	07/31/1998	09/12/1998					
FSPA No. 5	SWRI	RW	07/30/1998	09/02/1998					
FSPA No. 5	SWRI	WR	07/29/1998	08/13/1998					
FSPA No. 6	CHEMTECH	SB	09/22/1998	10/29/1998					
FSPA No. 6	CHEMTECH	SD	10/07/1998	10/07/1998					
FSPA No. 6	CHEMTECH	SS	09/22/1998	10/29/1998					
FSPA No. 6	COLUMBWA	DF	09/22/1998	11/01/1998					
FSPA No. 6	COLUMBWA	PR	09/24/1998	10/21/1998					
FSPA No. 6	COLUMBWA	TI	09/23/1998	10/21/1998					
FSPA No. 6	LAUCKS	WR	09/22/1998	10/23/1998					
FSPA No. 6	SENTINEL	SB	09/22/1998	10/28/1998					
FSPA No. 6	SENTINEL	SD	10/16/1998	10/24/1998					
FSPA No. 6	SENTINEL	SS	09/22/1998	10/28/1998					
FSPA No. 7	SVL	SB	07/16/1998	08/01/1998					
FSPA No. 7	SVL	SS	07/16/1998	08/01/1998					
FSPA No. 7	SWRI	SB	07/23/1998	07/30/1998					
FSPA No. 7	SWRI	SS	07/23/1998	07/30/1998					
FSPA No. 8	ARI	SB	10/23/1998	11/09/1998					
FSPA No. 8	ARI	SS	11/10/1998	11/10/1998					
FSPA No. 8	INCHVT	SB	10/27/1998	11/18/1998					

Table 4.2.3-3 (Continued)
FSPA Sample Collection and Analysis Summary—Soil Parameters

FSPA	Lab	Matrix	Collection Date First Sample	Collection Date Last Sample	TOC	ABA	AVS/ SEM	Grain-size	Specific Gravity
FSPA No. 8	INCHVT	SS	10/25/1998	11/10/1998					
FSPA No. 8	LAUCKS	GW	12/03/1998	12/08/1998					
FSPA No. 8	LAUCKS	SB	10/23/1998	11/18/1998		76			
FSPA No. 8	LAUCKS	SS	10/25/1998	12/21/1998		44			
FSPA No. 8	LAUCKS	SW	11/12/1998	12/07/1998					
FSPA No. 8	SWOK	SS	12/21/1998	12/21/1998					
FSPA No. 8	SWRI	GW	12/01/1998	12/09/1998					
FSPA No. 8	SWRI	SW	11/11/1998	12/09/1998					
FSPA No. 9	CAS	SW	08/17/1999	08/17/1999					
FSPA No. 9	Field XRF	DR	10/02/1998	10/06/1998					
FSPA No. 9	Field XRF	FI	10/13/1998	10/13/1998					
FSPA No. 9	Field XRF	FL	10/03/1998	10/05/1998					
FSPA No. 9	Field XRF	PL	10/03/1998	10/12/1998					
FSPA No. 9	Field XRF	RK	10/02/1998	10/13/1998					
FSPA No. 9	Field XRF	SD	10/12/1998	10/12/1998					
FSPA No. 9	Field XRF	SL	10/02/1998	10/13/1998					
FSPA No. 9	Field XRF	SU	10/13/1998	10/13/1998					
FSPA No. 11A	MEL	GW	11/30/1999	12/06/1999					
FSPA No. 11A	MEL	SW	12/01/1999	12/06/1999					
FSPA No. 11A	SWRI	GW	11/30/1999	12/06/1999					
FSPA No. 11A	SWRI	SW	12/01/1999	12/06/1999					
FSPA No. 12	SENTINEL	SB	04/30/1999	05/18/1999					
FSPA No. 12	SENTINEL	SS	04/30/1999	05/18/1999					
FSPA No. 12	SWRI	WR	05/03/1999	05/15/1999					
FSPA No. 13	CHEMTECH	SB	08/24/1999	09/14/1999					
FSPA No. 13	CHEMTECH	SS	08/24/1999	09/14/1999					
FSPA No. 13	SENTINEL	SB	08/25/1999	08/28/1999					
FSPA No. 13	SENTINEL	SS	08/25/1999	08/28/1999					
FSPA No. 15	CHEMTECH	SB	09/01/1999	09/10/1999					
FSPA No. 15	HONG WEST	SB	09/01/1999	09/09/1999				28	
FSPA No. 15	SENTINEL	SB	09/01/1999	09/09/1999					
FSPA No. 15	SOIL TECH	SB	09/01/1999	09/03/1999				21	
FSPA No. 16	AATS	SB	03/30/2000	03/30/2000					
FSPA No. 16	AATS	SS	03/30/2000	03/30/2000					
FSPA No. 16	CHEMTECH	SB	03/27/2000	03/27/2000					
FSPA No. 16	CHEMTECH	SS	03/23/2000	03/31/2000					
FSPA No. 16	MEL	WR	03/23/2000	03/30/2000					
FSPA No. 16	OTHER	SB	03/30/2000	03/30/2000					

Table 4.2.3-3 (Continued)
FSPA Sample Collection and Analysis Summary—Soil Parameters

FSPA	Lab	Matrix	Collection Date First Sample	Collection Date Last Sample	TOC	ABA	AVS/ SEM	Grain-size	Specific Gravity
FSPA No. 16	OTHER	SS	03/29/2000	03/31/2000					
FSPA No. 16	SENTINEL	SL	03/21/2000	03/23/2000					
FSPA No. 16	SENTINEL	SB	03/21/2000	03/30/2000					
FSPA No. 16	SENTINEL	SS	03/21/2000	03/31/2000					

Notes:
ABA - acid base accounting
AVS/SEM - acid volatile sulfides/simultaneously extractable metals
DF - Dust
DR - Debris/rubble
FI - Filter material
FL - Forest litter
FSPA - field sampling plan addendum
GW - Groundwater
PL - Plant
PR - Product
RK - Rock/cobbles/gravel
RW - Disturbed water
SB - Soil Boring
SD - Sediment
SL - Soil
SS - Surface Soil
SU - Sludge
SW - Surface Water
TI - Tissue
WR - Water

Table 4.2.3-4
Summary of the Geophysical/Bathymetry Survey for FSPA No. 1

Area	Number of Transects	Number of Locations or Measuring Points
Cataldo	3	50
Dudley	11	176
Killarney	8	133
Medimont	6	153
Swan	6	142
Harrison	6	149
Total	40	803

Note: Data summarized in Section 4, Parts 2-6 and Appendix A of this RI.

Table 4.2.3-5
Summary of Sediment Core Samples Collected for FSPA No. 1

Area	Transect or Lake	Number of Cores	Number of Environmental Samples	Number of Field Duplicates	Total Number of Samples
Coeur d'Alene Main Stem	Cataldo	7[a]	33	3	36
	Harrison	8[a,b]	28	3	31
	Medimont	7[a]	28	3	31
	Swan	8[a,b]	28	3	31
	Delta	1	6	0	6
	Sub-Total	31	123	12	135
Lateral Lakes	Cave Lake	5[b]	6	1	7
	Killarney Lake	5[b]	10	1	11
	Medicine Lake	5[b]	9	1	10
	Rose Lake	5[b]	9	1	10
	Sub-Total	20	34	4	38
Coeur d'Alene River Floodplain	Cataldo	9	26	2	28
	Dudley	5	10	1	11
	Harrison	6	15	2	17
	Killarney	10	25	2	27
	Medimont	10	24	2	26
	Swan	8	18	2	20
	Sub-Total	48	118	11	129
Total		99	275	27	302

[a]This quantity includes two USGS cores.
[b]This quantity includes one archive core.

Note: Data summarized in Section 4, Parts 2-6 and Appendix A of this RI.

Table 4.2.3-6
Summary of Surface Water Creek/River Samples for FSPA No. 2

Samples	South Fork	South Fork Tributaries	Canyon Creek	Ninemile Creek	Pine Creek	Down-stream	Total
Number of Planned Environmental Samples	25	71[a]	17	17	10	0	140[a]
Number of Environmental Samples Added in the Field	0	1	9	0	0	7	16
Number of Environmental Samples Collected	24	43	25[b]	16	9	7	124
Number of Field Duplicates Collected	3	3	3	1	2	1	13
Total Number of Samples Collected	27	46	28	17	11	8	137

[a]This includes up to 25 additional samples along previously unsampled tributaries. These additional samples would only be obtained if high metals concentrations were detected in the tributary at the confluence with the South Fork. However, the 25 additional samples were not collected due to weather conditions.
[b]Nine locations were resampled in January after construction activities on Canyon Creek ceased. This number includes the samples taken during the January resampling.

Note: Data summarized in Section 4, Parts 2-6 and Appendix A of this RI.

Table 4.2.3-7
Summary of Sediment Samples Collected for FSPA No. 3

General Area	No. of Transects	No. of Environmental Samples	No. of Field Duplicates	Total No. of Samples
Canyon Creek	5	14	2	16
Ninemile Creek	5	19	2	21
Pine Creek	11	49	4	53
South Fork	19	47	4	51
Total	40	129	12	141

Note: Data summarized in Section 4, Parts 2-6 and Appendix A of this RI.

Table 4.2.3-8
Summary of Surface Water Creek/River Samples for FSPA No. 4

Samples	South Fork	South Fork Tributaries	Canyon Creek	Ninemile Creek	Pine Creek	North Fork	Down-stream	Total
Number of planned environmental samples – URS	25	52	17	17	19	47	7	184
Number of planned environmental samples – USGS	18[a]	12[b]	6[c]	6[c]	6[c]	6[c]	0	54
Number of locations added in the field	0	1	1	0	0	2	0	4
Number of environmental samples collected by URS	19	51	17	17	17	46	7	174
Number of environmental samples collected by USGS	3[d]	2[d]	1[d]	1[d]	1[d]	1[d]	0	9
Number of field duplicates collected	2	4	2	2	1	6	0	17
Total number of samples collected (URS and USGS Combined)	24	57	20	20	19	53	7	200

[a]This includes 6 samples at each of 3 stations.
[b]This includes 6 samples at each of 2 stations.
[c]This includes 6 samples at 1 station.
[d]Only one sample was collected at each station.

Note: Data summarized in Section 4, Parts 2-6 of RI and Appendix A of the RI.

Table 4.2.3-9
Summary of Soil and Sediment Samples Collected for Task 2 of FSPA No. 5

General Area	No. of CUAs	Number of Samples		
		Environmental	Field Duplicates	Total Samples
Wet Beach Sediments				
Spokane River and Coeur d'Alene Lake	22	140	15	155
Coeur d'Alene River	23	112	10	122
South Fork	2	9	1	10
Totals	47	261	26	287
Dry Beach Sediments				
Spokane River and Coeur d'Alene Lake	17	153	13	166
Coeur d'Alene River	19	95	15	110
South Fork	2	15	2	17
Totals	38	263	30	293
Total Sediments				
Spokane River and Coeur d'Alene Lake	22	293	28	321
Coeur d'Alene River	24	207	25	232
South Fork	2	24	3	27
Totals	48	524	56	580
Soil				
Spokane River and Coeur d'Alene Lake	12	90	10	100
Coeur d'Alene River	31	155	21	176
South Fork	15	895	98	993
Totals	58	1,140	129	1,269
Total Soil and Sediments				
Spokane River and Coeur d'Alene Lake	24	383	38	421
Coeur d'Alene River	31	362	46	408
South Fork	16	919	101	1,020
Totals	71	1,664	185	1,849

Note:
CUA - common use area
Data summarized in Section 4, Parts 2-6 and Appendix A of this RI and in the Human Health Risk Assessment.

Table 4.2.3-10
Summary of Surface Water Samples Collected for Task 3 of FSPA No. 5

General Area	No. of CUAs	No. of Environmental Samples	No. of Field Duplicates	Total No. of Samples
Spokane River and Lake Coeur d'Alene	23	162	17	179
Coeur d'Alene River	23	115	15	130
South Fork	2	10	2	12
All Areas Combined	48	287	34	321

Note:
CUA - common use area
Data summarized in Section 4, Parts 2-6 of this RI and in the Human Health Risk Assessment.

Table 4.2.3-11
Summary of Drinking Water Samples Collected for Task 4 of FSPA No. 5

General Area	No. of CUAs	No. of Environmental Samples	No. of Field Duplicates	Total No. of Samples
Spokane River and Lake Coeur d'Alene	2	2	0	2
Coeur d'Alene River	2	2	0	2
South Fork	0	0	0	0
All Areas Combined	4	4	0	4

Note:
CUA - common use area
Data summarized in Section 4, Parts 2-6 and Appendix A of this RI and in the Human Health Risk Assessment.

Table 4.2.3-12
Quantity of Residential Samples Collected During Implementation of FSPA No. 6

Task	Sub-Task	No. of Environmental Samples	No. of Field Duplicates	Total No. of Samples
Task 1–outdoor soils (yard soils)	Play area, garden plot, and lawn/open area soils	1,642	158	1,800
Task 1–outdoor soils (yard soils)	High-biased area soils	180	61	241
Total Task 1–outdoor soils (yard soils)		1,822	219	2,041
Total Task 2–garden produce		35[a]	2	37
Total Task 3–drinking water		178	16	194
Task 4–indoor dust	Floor mats	84	12	96
Task 4–indoor dust	Vacuum cleaner bags	77	7	84
Task 4–indoor dust	Paint chips	51	4	55
Total Task 4		212	23	235
Total Task 5–other potential exposure media		3	1	4
Total all tasks		2,250	261	2,511

[a]Forty-five environmental garden produce samples were collected, but only 35 were analyzed because an insufficient quantity of sample was collected.

Note: Data summarized in the Human Health Risk Assessment and partially in Section 4, Parts 2-6 and Appendix A of this RI.

Table 4.2.3-13
Quantity of Residential Soil Samples Collected During Implementation of FSPA No. 7

Location ID	Location Description	No. of Environmental Samples	No. of Field Duplicates	Total No. of Samples
101	Lawn/open area	94	14	108
102	Gravel driveway	40	3	43
103	Child's play area	24	1	25
104	Garden plot	21	2	23
105	Other discrete areas: secondary gravel driveway/parking area/ walkway	10	0	10
105	Other discrete areas: adjacent lot	4	0	4
105	Other discrete areas: secondary child's play area	4	1	5
105	Other discrete areas: secondary garden area	3	1	4
106	Other discrete areas: sand pile	1	0	1
120	Other discrete areas: unimproved area	4	0	4
201	Black crystalline material	1	0	1
Total all locations		206	22	228

Note: Data summarized in the Human Health Risk Assessment and partially in Section 4, Parts 2-6 and Appendix A of this RI.

Table 4.2.3-14
Summary of Subsurface Soil Samples for Task 1, FSPA No. 8

Subsurface Soil Samples	Canyon Creek	Ninemile Creek	Pine Creek	Total
Number of planned sampling locations	37	8	0	45
Number of planned environmental samples	74	19	0	93
Number of environmental samples added in the field	0	0	2	2
Number of locations sampled	32	8	1	41
Number of environmental samples collected	60	15	2	77
Number of field duplicates collected	5	0	0	5
Total number of samples collected	65	15	2	82

Note: Data summarized in Section 4, Parts 2-6 and Appendix A of this RI.

Table 4.2.3-15
Summary of Groundwater Samples for Task 2, FSPA No. 8

Groundwater Samples	Canyon Creek	Ninemile Creek	Pine Creek	Total
Number of planned sampling locations	37	8	2[a]	47
Number of planned environmental samples	66	15	4[a]	85
Number of locations sampled	33	6	2	41
Number of environmental samples collected	64	16	4	84
Number of field duplicates collected	5	2	0	7
Total number of samples collected	69	18	4	91

[a]This includes one domestic water supply well.

Note: Data summarized in Section 4, Parts 2-6 and Appendix A of this RI.

Table 4.2.3-16
Summary of Ground Surface Soil Samples for Task 3, FSPA No. 8

Surface Soil Samples	Canyon Creek	Ninemile Creek	South Fork	Total
Number of planned environmental samples	24[a]	15	25[b]	64
Number of environmental samples added in the field	0	2	0	2
Number of environmental samples collected	22	17	5	44
Number of field duplicates collected	3	1	1	5
Total number of samples collected	25	18	6	49

[a]This includes one sample of precipitate under the Gem outfall.
[b]This includes five samples at the Mullan Dump.

Note: Data summarized in Section 4, Parts 2-6 and Appendix A of this RI.

Table 4.2.3-17
Summary of Surface Water Samples for Task 4, FSPA No. 8

Surface Water Samples	Canyon Creek	Ninemile Creek	South Fork	Pine Creek	Total
Number of planned sampling locations	29	26	12	2	69
Number of planned environmental samples	29[a]	26	12	2	69
Number of environmental samples added in the field	0	1	0	0	1
Number of locations sampled	26	27	5	2	60
Number of environmental samples collected	34	31	5	2	72
Number of field duplicates collected	3	3	1	0	7
Total number of samples collected	37	34	6	2	79

[a]This includes one outfall sample from the Gem outfall.

Note: Data summarized in Section 4, Parts 2-6 and Appendix A of this RI.

Table 4.2.3-18
Quantity of Groundwater and Surface Water Samples Collected for FSPA No. 11A

Location	Environmental Samples	Field Duplicates	Total
Canyon Creek			
Monitoring wells	45	5	50
River stations	19	1	20
Ninemile Creek			
Monitoring wells	8	1	9
River stations	2	1	3
Pine Creek/South Fork			
Monitoring wells	2	0	2
River stations	1	0	1
Total	77	8	85

Note: Data summarized in Section 4, Parts 2-6 and Appendix A of this RI.

Table 4.2.3-19
Quantity of Residential Samples Collected for FSPA No. 12

Task	Sub-Task	No. of Environmental Samples	Number of Field Duplicates	Total No. of Samples
Task 1—yard soils	Garden area	24	3	27
Task 1—yard soils	Gravel drive	19	3	22
Task 1—yard soils	Downspout area (high-biased)	58	11	69
Task 1—yard soils	Play area	4	0	4
Task 1—yard soils	Yard area	661	61	722
Task 2—drinking water		26	4	30
Total		792	82	874

Note: Data partly summarized in Section 4, Parts 2-6 and Appendix A of this RI. All data summarized in the Human Health Risk Assessment.

Table 4.2.3-20
Summary of Soil Samples Collected for Task 1 of FSPA No. 13

Site ID	Number of Sample Locations Established	Number of Environmental Samples Collected	Number of Field Duplicates Collected	Total Number of Samples Collected
SD001 – Private Day Care1	8	24	2	26
SD002 – Private Day Care2	4	11	1	12
Private Day Care3	NC	NC	NC	NC
Tiger Day Care	NC	NC	NC	NC
Playtime Day Care	NC	NC	NC	NC
SD004 – Canyon Elem. Basketball Crt.	2	9	1	10
SD005 – Canyon Elem. Ballfields	2	8	1	9
SD006 – Canyon Elem. Play Areas	7	28	3	31
SD007 – Mullan High School Public Area	19	76	8	84
SD008 – Mullan High School Play area	19	77	8	85
SD009 – Mullan Elem.	19	77	8	85
Mullan High School Football Field	NC	NC	NC	NC
Mullan HS Parking Lot	NC	NC	NC	NC
Mullan HS Other Open Areas	NC	NC	NC	NC
SD013 – Mullan Athletic Pavilion	7	29	3	32
SD014 – Silver Meadow Play Area	1	5	0	5
SD015 – Silver Meadow Driveway	7	14	1	15
SD016 – Silver Meadow Ballfield	1	5	0	5
SD017 – Rainy Hill	20	40	4	44
SD018 – Killarney Rd.	7	7	1	8
Total	120	410	41	451

Note:
NC - Not collected; samples were not collected during field activities.
Note: Data partly summarized in Section 4, Parts 2-6 and Appendix A of this RI, and completely summarized in the Human Health Risk Assessment.

Table 4.2.3-21
Summary of Soil Samples Collected for Task 2 of FSPA No. 15, From the Spokane River

Analysis Type	Number of Environmental Samples Collected	Number of Field Duplicates Collected	Total Number of Samples Collected
80-Mesh Sieve	126	16	142
Bulk	49	7	56
Grain Size	49	6	55
Total	224	29	253

Note: Data summarized in Section 4, Parts 2-6 and Appendix A of this RI.

Table 4.2.3-22
Quantity of Samples Collected for FSPA No. 16

Sampling Location	Number of Environmental Samples	Number of Field Duplicates	Total Number of Samples
Soil Samples			
Yard	1,200	125	1,325
Play Area	16	2	18
Garden	8	2	10
Driveway	39	5	44
Down spout	55	19	74
Mullan Football Field	94	8	102
Water Samples			
First draw water	15	2	17
Purged water	15	2	17
Equipment Rinsates	11	NA	11
Totals	**1,453**	**165**	**1,618**

Table 4.2.3-23
Summary of Sediment Samples Collected for FSPA No. 18

Analysis	Environmental Samples	Quality Control Samples		
		Field Duplicates	MS/D	Total Samples
Field				
Sieve to 80-mesh [a]	189	-	-	189
FPXRF [b]	243	21	-	264
Laboratory (Confirmation Analysis)				
Target analyte list metals [c]	23	3	2/2	30

[a] Field sieved random and bank profile samples; did not field sieve bulk samples
[b] Collected FPXRF data for random, bank profile, and bulk samples
[c] Submitted one sample from each depositional area for confirmation analysis (excluding CUAs 203 and 204)

Notes:
FPXRF - field portable x-ray fluorescence
MS/D - matrix spike/duplicate

Table 4.2.4-1
Probability Analysis That the True Average or Mean Concentration of a Given Source Type is Above Screening Levels

Source Type	Units	Screening Level	Sample Statistics		Probability Concentration is Above Screening Level
			Average	Coefficient of Variation	
Arsenic					
Adit Drainage - Dissolved Metals Concentrations (n=38)	µg/L	150	1.63	2.29	0%
Floodplain Sediments (n=390)	mg/kg	13.6	77.5	1.22	91%
Floodplain Tailings (n=25)	mg/kg	13.6	134	1.50	94%
Floodplain Waste Rock (n=10)	mg/kg	13.6	485	1.59	100%
Upland Concentrates and Process Wastes (n=3)	mg/kg	22	140	0.25	100%
Upland Tailings (n=26)	mg/kg	22	36.0	1.00	57%
Upland Waste Rock (n=38)	mg/kg	22	258	2.59	84%
Cadmium					
Adit Drainage - Dissolved Metals Concentrations (n=141)	µg/L	0.38	11.5	2.82	94%
Floodplain Sediments (n=446)	mg/kg	1.56	31.8	1.75	97%
Floodplain Tailings (n=19)	mg/kg	1.56	24.9	1.30	99%
Floodplain Waste Rock (n=15)	mg/kg	1.56	7.78	0.97	94%
Upland Concentrates and Process Wastes (n=3)	mg/kg	9.8	213	0.22	100%
Upland Tailings (n=52)	mg/kg	9.8	26.4	2.17	54%
Upland Waste Rock (n=96)	mg/kg	9.8	20.1	2.24	45%
Lead					
Adit Drainage - Dissolved Metals Concentrations (n=240)	µg/L	1.09	42.4	4.47	89%
Floodplain Sediments (n=496)	mg/kg	51.5	6,320	1.65	100%
Floodplain Tailings (n=25)	mg/kg	51.5	4,250	0.99	100%
Floodplain Waste Rock (n=15)	mg/kg	51.5	1,360	1.66	99%
Upland Concentrates and Process Wastes (n=3)	mg/kg	171	18,500	1.01	100%
Upland Tailings (n=58)	mg/kg	171	8,420	1.56	100%
Upland Waste Rock (n=98)	mg/kg	171	7,460	1.62	100%
Zinc					
Adit Drainage - Dissolved Metals Concentrations (n=150)	µg/L	42	1,700	2.92	96%
Floodplain Sediments (n=475)	mg/kg	200	4,900	2.58	94%
Floodplain Tailings (n=25)	mg/kg	200	3,880	1.24	100%
Floodplain Waste Rock (n=15)	mg/kg	200	1,220	1.52	87%
Upland Concentrates and Process Wastes (n=3)	mg/kg	280	53,700	0.21	100%
Upland Tailings (n=57)	mg/kg	280	8,460	3.25	92%
Upland Waste Rock (n=99)	mg/kg	280	5,850	3.65	85%

Note: n - number of available sample results

5.0 EVALUATION METHODOLOGY

This section describes methods used to evaluate chemical and physical data compiled for the remedial investigation. Described are the selection of appropriate screening levels, including risk-based screening concentrations and upper background concentrations, the derivation of the upper background concentrations used to evaluate soil and surface water data, the methods and data sources used to calculate mass loading of chemicals of potential concern (COPCs) to the Coeur d'Alene River and Coeur d'Alene Lake, and the methods used to evaluate chemical and physical fate and transport processes.

5.1 SELECTION OF SCREENING LEVELS

Based on the results of the human health and ecological risk assessments, 10 COPCs were initially identified for inclusion and evaluation in the RI. During the Human Health and Ecological Risk Assessments, the initial COPCs were evaluated and those that met the data evaluation requirements and screening against applicable risk-based screening criteria incorporated. The COPCs and appropriate corresponding media (soil, sediment, groundwater, and surface water) are summarized in Table 5.1-1. For each of the COPCs listed in Table 5.1-1, a screening level was selected. COPCs not carried forward in the Human Health Risk Assessment were copper and silver. COPCs not carried forward in the Ecological Risk Assessment were antimony, iron, and manganese. Drinking water, residential soil, house dust, and garden produce data were evaluated separately in the Human Health Risk Assessment.

The screening levels were used in the RI to help identify source areas and media of concern that would be carried forward for evaluation in the feasibility study (FS). The screening levels that were selected for use in the RI are not intended as proposed cleanup levels in the FS. The following paragraphs discuss the rationale for the selection of the screening levels.

Applicable risk-based screening levels and upper background concentrations were compiled from available federal numeric criteria (e.g., National Ambient Water Quality Criteria), regional preliminary remediation goals (PRG) (e.g., U.S. EPA Region IX PRG), regional background studies for sediment, soil, and surface water, and other guidance documents (e.g., National Oceanographic and Atmospheric Administration freshwater sediment screening values). Applicable risk-based screening levels and available background concentrations used to select RI screening levels are listed in Tables 5.1-2 through 5.1-8. Selected RI screening levels are listed in Tables 5.1-9 through 5.1-11.

For the evaluation of site soil, sediment, groundwater, and surface water chemical data, the lowest available risk-based screening level for each media was selected as the screening level. If the lowest risk-based screening level was lower than the available background concentration, the background concentration was selected as the screening level.

Groundwater data are screened against surface water screening levels to evaluate the potential for impacts to surface water from groundwater discharge.

For site groundwater and surface water, total and dissolved metals data are evaluated separately. Risk-based screening levels for protection of human health (consumption of water) are based on total metals results, therefore, total metals data for site groundwater and surface water were evaluated against screening levels selected from human health risk-based screening levels. Risk-based screening levels for protection of aquatic life are based on dissolved metals results, therefore, dissolved metals data for site groundwater and surface water were evaluated against screening levels selected from aquatic life risk-based screening levels.

For evaluation of the nature and extent of the 10 chemicals of potential concern in site soil, sediment, groundwater, and surface water, data are compared to 1x, 10x, and 100x the screening levels to illustrate the magnitude of any screening level exceedances. Statistical summaries for each chemical in surface soil, subsurface soil, sediment, groundwater (total and dissolved), and surface water (total and dissolved) were generated for each watershed segment. The statistical summaries include the number of samples analyzed; the number of detections; the minimum and maximum detected concentrations; the average and coefficient of variation; and the screening level to which the detected concentration is compared. Data evaluated for each watershed segment are included in data summary tables at the end of each watershed report section. Data summary tables include sample location and depth, sample collection date, and reported concentration. Sample locations are shown on figures for soil/sediment, groundwater, and surface water generated for each watershed segment.

Potentially significant source areas are identified using the available chemical data, sample location maps, and source areas currently identified by the Bureau of Land Management. Sample locations associated with these source areas are identified and individual source area statistical summaries are presented in the same format as for each watershed segment. Chemical data for surface soil, subsurface soil, sediment, groundwater, and surface water are then reviewed together to identify source areas within each watershed segment that may be significant contributors of metals.

To facilitate the evaluation of chemical fate and transport, all 10 chemicals in all four matrices (soil, sediment, groundwater, and surface water) are included in the discussion regardless of whether the concentration of the chemical in the particular segment exceeds the screening level.

5.2 DETERMINATION OF BACKGROUND CONCENTRATIONS

For the purpose of determining which portions of the Coeur d'Alene Basin would be considered contaminated and thus evaluated in the RI/FS, concentrations of metals in environmental media (soil-sediment and surface water) were compared with background concentrations. Background concentrations have been determined for soils, sediments, and surface waters as described in the following sections. A detailed discussion of determination of background concentrations is provided in the Final Technical Memorandum (Rev. 2) Estimation of Background Concentrations in Soil, Sediment, and Surface Water in the Coeur d'Alene and Spokane River Basins (URSG and CH2M HILL 2001).

5.2.1 Soil and Sediment

The development of background ranges was conducted separately for soil and sediment in each of the major portions of the Coeur d'Alene Basin. These are briefly described below:

Upper Basin (CSM Units 1 and 2) Soil Background Concentrations. The principal source of data on background concentrations of metals in soil in the Coeur d'Alene Basin is a geological study conducted by Gott and Cathrall (1980). Gott and Cathrall sampled soils at approximately 8,700 locations in the upper Coeur d'Alene River basin (CSM Units 1 and 2). Samples were collected opportunistically throughout the Basin for the purpose of examining the use of near-surface background soil metals concentrations to determine the location of economically exploitable minerals deposits. Near-surface rather than surface samples were collected to avoid potential bias of their results by metals deposited throughout the region by past emissions from the lead smelter at Smelterville. Summary statistics from Gott and Cathrall (1980) for ten metals are presented in Table 5.2.1-1. These include the 25th, 50th, 75th, and 90th percentiles of the distribution of background concentrations.

To account for the possibility that soil background concentrations may not be representative of background concentrations in sediments in Upper Basin, background sediment metals concentrations were estimated from sediment data collected from monitoring well boreholes for the RI/FS. Summary statistics from this analysis, including percentile ranges and the 95 percent upper confidence limit (95 percent MCL) on the geometric mean, are presented in Table 5.2.1-2.

(A background concentration could not be estimated for silver because of the large number of non-defects in the background data set).

Comparison of the values presented in Tables 5.2.1-1 and 5.2.1-2 tend to affirm the contention of LeJeune and Cacela (1999) that the Gott and Cathrall data probably are biased high for most metals. Comparing the 90th percentile values for the Gott and Cathrall soil data with the 90th percentile sediment values calculated in this document indicates that the calculated sediment values are lower than the calculated soil values for nine of the 10 metals for which a comparison can be made.

Lower Basin (CSM Units 3 and 4) Soil and Sediment Background Concentrations. Upper Basin soil and sediment background ranges were assumed to not be representative of Lower Basin sediment background. To confirm this assumption, available studies on sediment background concentrations in the Lower Basin were reviewed, and sediment background ranges were estimated from data collected for the RI/FS. The results of the analysis of RI/FS data, including percentiles of the distribution and the 95 percent UCL on the geometric mean of the data, are presented in Table 5.2.1-3. (A background concentration range could not be estimated for mercury in Lower Basin sediments due to the large proportion of non-detects in the data set.)

Comparison of the Upper Basin sediment background concentrations to the estimated Lower Basin sediment background concentrations (Tables 5.2.1-2 and 5.2.1-3) shows a distinct decline in the upper bound of background concentrations between the Upper and Lower Basin for eight of the ten metals that can be compared. This decline in concentrations is logical, considering the large contribution of sediments from the less mineralized North Fork Coeur d'Alene River to the total Lower Basin sediment load. The calculated ranges presented in Table 5.2.1-3 are selected as representative of soil and sediment COPC background concentrations for Lower Basin (CSM Units 3 and 4).

Spokane River Basin (CSM Unit 5) Soil and Sediment Background Concentrations. The Washington Department of Ecology (WDOE) collected soil samples in the Spokane Basin for the express purpose of determining natural background concentrations for metals (WDOE 1994). These data were provided to URS by WDOE (C. San Juan, Feb. 7, 2001) and were analyzed using the "MTCA *Stat* 97 Background Module" (WDOE 1997). The 5th, 90th, and 95th percentiles and the 95 percent UCL on the mean of the data sets were calculated.

For the RI/FS, the best estimates of background sediment concentrations in the Spokane River Basin are assumed to lie somewhere between the WDOE ranges and the background concentration ranges for sediments in the Lower Coeur d'Alene Basin (presented in the previous section). For most metals, the calculated background values between studies for soils and sediments in the Spokane River Basin were in relatively good agreement. Consequently, the WDOE soil data were accepted as representative of soil and sediment background concentrations in the Spokane River Basin. These data are summarized in Table 5.2.1-4.

5.2.2 Surface Water

Background concentrations of metals in surface water in the Coeur d'Alene Basin were calculated using the approach described in Stratus (2000a). The limited information on surface water that is available for the Basin does not allow a general estimate of background. The available information for surface water background will be discussed for specific locations in the upper Coeur d'Alene River basin.

Stratus (2000) accounted for differences in mineralization and watershed properties to determine "baseline" (synonymous with background) concentrations of dissolved cadmium, lead, and zinc in three areas of the Coeur d'Alene River basin: the Upper South Fork, the Page-Galena mineral belt area, and the Pine Creek drainage. In addition, pooled baseline values were determined for all three areas combined, which is referred to as the "entire South Fork Coeur d'Alene River basin." They identified characteristic sampling locations for each of the four portions of the basin, and using data collected by EPA, the U.S. Geological Survey, and Idaho Department of Environmental Quality (IDEA) they calculated the median and 25th and 75th percentiles for the three metals in each of the three areas and for the Basin as a whole.

Using the same sampling locations, except as noted in Appendix B, the same parameters were calculated for all of the surface water COPCs (Table 5.2.2-1). Table 5.2.2-1 also shows the national chronic AWQC calculated at a hardness of 30 mg/L as $CaCO_3$, a hardness that is toward the lower end of the range for the mining-affected portions of the Basin.

All median values for background surface water were below the national chronic AWQC. The 95th percentile of the background dissolved lead concentrations exceeded the national chronic AWQC calculated at a hardness of 30 mg/L as $CaCO_3$ in the following areas: the Upper South Fork of the Coeur d'Alene River, the Page-Galena mineral belt area, and in the South Fork basin as a whole ("entire South Fork"). The 75th percentile of the data exceeded the national chronic criteria in the Page-Galena mineral belt area (Table 5.2.2-1). These results imply that the national criteria would only be exceeded in a very limited number of mineralized locations in the stated drainages at some times. All of the calculated values for zinc and cadmium, including the 95th percentile, were well below the national AWQC.

The statistics reported in Table 5.2.2-1 need to be qualified because all of the distributions were affected by the fact that many samples did not have detectable amounts of metals. In those instances, one-half of the detection limit was taken to represent the value for the metal in the sample. Silver was not detected in any sample, so the entire distribution is based on the variability of one-half of the detection limits, which ranged from 0.03 to 0.3 mg/L. Mercury was detected in one sample of 69 at 2.61 mg/L, with detection limits from 0.16 to 0.20 mg/L. In that case, the median, 25th percentile, and 75th percentile all are just one-half of the detection limit for the respective samples, and the 95th percentile for the Page-Galena Mineral Belt is the average of the sample with 2.61 mg/L and one-half of the detection limit of the next-highest (not detected) sample. For silver and mercury, it can only be said that background concentrations are likely to be less than the respective detection limits in the data summarized in Table 5.2.2-1. For all of the other metals there were enough detected values that the 75th and 95th percentiles have credibility, but the medians (except for zinc) and 25th percentiles were determined by one-half of the variable detection limits. Detection limits for lead ranged from 0.1 to 3 mg/L. Detected concentrations of lead range from 0.1 to 3.95 mg/L, about the same range as the variable detection limits, so the 75th percentile is based on a detected value. Lead was detected in only 30 of 128 samples in the background data set. Zinc was detected in 91 of 128 samples, so the median is also based on a detected value.

Examination of Table 5.2.2-1 shows that there are some possible differences in background concentrations of metals in surface water, depending on the geology of the source areas. The national AWQC are appropriate screening levels for surface water and near-surface groundwater that could be or is discharging to surface waters. Watersheds, where background lead concentrations could exceed the national hardness-based chronic AWQC in limited highly mineralized areas, are accounted for in this report.

5.3 MASS LOADING OVERVIEW AND DATA SOURCES

Section 5.3.1 presents an overview of mass loading, including a definition of mass loading, calculation procedures, data collection methods, and potential sources of data interpretation uncertainty. Section 5.3.2 presents a summary of sources of mass loading data in the Coeur d'Alene River basin, including a summary of the scope and a discussion, where applicable, of potential data quality issues associated with each of the investigations.

Mass loading was evaluated using two different methods. Methods for calculating point estimates of mass loading from discrete discharge and concentration data are presented in this section. Methods for estimating average mass loading using a combined data set and a probabilistic model are presented in Section 5.4, Fate and Transport Evaluation.

5.3.1 Overview

Mass loading is the weight of a constituent passing a given point per unit time, and is expressed in this RI in pounds per day. Mass loading is measured by conducting stream gaging and chemical analysis of water samples, and is calculated as the product of stream discharge and constituent concentration. In this RI, stream discharge is expressed in cubic feet per second and constituent concentration in micrograms per liter. The product of stream discharge and constituent concentration is multiplied by a conversion factor equal to 0.00538 (lb-L-sec)/(ft^3-μg-day) to compute the mass loading in pounds per day.

Ideally, mass loading data are collected by following a slug of water from upstream to downstream. This method of collecting data, referred to as synoptic sampling, is used to prepare a "snapshot" of mass loading in the stream that can be used to evaluate the sources of mass loading. In reality, a true synoptic sampling is rarely achieved. Sampling usually occurs over a period of one to several days. When stream discharge varies little during the sampling period (a steady-state flow condition), the data may be considered to reflect a synoptic sampling. Steady-state flow conditions usually were present during low-flow sampling events conducted in the basin.

Data comparability between sampling stations is reduced when the stream discharge varies significantly during the sampling period (a non-steady-state flow condition). Non-steady-state flow conditions are usually present during and for some time after a significant precipitation event and during snowmelt periods (e.g., high-flow event). Non-steady-state flow conditions can have an important effect on mass loading data because mass loading at a stream location generally increases with increasing discharge. This is particularly true for total loadings of metals that associate strongly with sediment, for example, lead, because sediment loading generally increases exponentially with discharge. At high flow conditions, total lead loadings can be one or more orders of magnitude greater than dissolved loadings, and total zinc and cadmium loadings may be up to several times greater than dissolved loadings.

An additional source of bias during non-steady-state flow conditions results from hysteresis in constituent loads during increasing ("ascending limb") and decreasing ("descending limb") discharge periods. Hysteresis is present when the constituent loading has different values for a given discharge during the ascending and descending limbs of a hydrograph. Woods (2000a) measured greater constituent loadings during the ascending limb of a hydrograph relative to the descending limb at locations in South Fork Coeur d'Alene River basin. The occurrence of non-steady-state flow conditions during sampling events is noted in Section 5.3.2.

The USGS has developed standardized methods for collection of stream-flow data, computation of discharge, and quality assurance procedures (Buchanan and Somers 1968, 1969; Riggs 1968; Carter and Davidian 1968; Kennedy 1983, 1984). These procedures were generally used to measure streamflow during the mass loading sampling events conducted in the basin. Significant deviations from these procedures introduce additional uncertainty with respect to discharge rates and are described in Section 5.3.2.

5.3.2 Data Sources

This section presents a summary of the mass loading data investigations conducted within the Coeur d'Alene River basin. The scope and purpose of these investigations are discussed in this section and summarized in Table 5.3-1. Of these available data sets, only data sets representing sampling efforts covering broad geographic areas and high and low flow events in 1991, 1997, and/or 1998 were selected for use in calculating point estimates of mass loading. Sampling locations and collection dates associated with these five sampling efforts are summarized in Table 5.3-2.

5.3.2.1 Data Prior to 1991

Data prior to 1991 have been summarized by McCulley, Frick & Gilman (MFG 1991). MFG noted that standardized sampling stations and methods were not used among the different investigators and concluded that results could not be directly compared between investigations. These data were not used in the evaluations of chemical mass loading.

5.3.2.2 MFG Data

MFG conducted a high flow sampling event in May 1991 and a low flow sampling event in October 1991.

5.3.2.2.1 May 1991 High Flow Event. MFG collected mass loading data at 57 stations in the South Fork basin during the May 1991 high flow event (MFG 1991). The high flow event included 15 stations on the South Fork, 12 on Canyon Creek (plus 5 side streams or point sources), 9 on Ninemile Creek (plus 2 side streams or point sources), and 14 side streams (other than Canyon Creek and Ninemile Creek) or point-source discharges to the South Fork.

The high flow event was conducted during non-steady-state, high-flow conditions between May 14 to 18, 1991 and corresponded very closely with the peak spring runoff. Based on data at the USGS gaging station at Elizabeth Park (SF268), high flow for the season occurred on and around May 19 (2,020 cfs). By comparison, the daily average discharge values at this station for the May 14 to 17 period were 1,010 to 1,140 cfs and the discharge on May 18 jumped to 1,970 cfs.

Mass loading data measured on May 18 might not be comparable to data measured on May 14 through 17 due to increasing stream discharge. The increased discharge resulted in increased total recoverable metals concentrations. For example, a total recoverable lead concentration of 1,530 μg/L was measured at CC287 (MFG Station ID CC-10) on May 18, 1991. Total recoverable lead concentrations of 38 and 30 μg/L were measured at this station on May 15 and 17. The discharge increased from 180 cfs on May 17 to 398 cfs on May 18 at this station. At stations CC277 (MFG CC-80), CC276 (MFG CC-90), CC2 (MFG CC-100), and CC1 (MFG CC-110) located in the upper reaches of the Canyon Creek Watershed, only mass loading data from May 18 are available, and total recoverable metals concentrations at these stations appear anomalously high compared to downstream stations.

An anomalous increase in discharge was measured between adjacent stations CC-60 (83 cfs) and CC-50 (230 cfs) during the spring event. The discharges were measured within a period of 2 hours on May 17, 1991. A similar step increase in discharge in this reach has not been measured during any other event.

The MFG high flow data were used in the evaluations of chemical mass loading in the South Fork Watersheds.

5.3.2.2.2 October 1991 Low Flow Event. MFG collected mass loading data at 70 stations during the October 1991 low flow event (MFG 1992). The high flow event included 24 stations on the South Fork, 15 on Canyon Creek (plus 6 side streams or point sources), 11 on Ninemile Creek (plus 2 side streams or point sources), and 12 side streams (other than Canyon Creek and Ninemile Creek) or point-source discharges on the South Fork.

The low flow event was conducted during the period October 1 to 5, 1991. The sampling was conducted during steady-state, low-flow conditions. Based on data at the USGS gaging station at Elizabeth Park (SF268), low flow for the season occurred on and around October 15 (71 cfs). By comparison, the daily average discharge value at this station for the October 1 to 5 period was 77 cfs for each day.

The MFG low-flow data were used in the evaluations of chemical mass loading in the South Fork Watersheds.

5.3.2.3 IDEQ Data

IDEQ collected mass loading data beginning in September 1993. The sampling was typically conducted monthly, with selected bimonthly sampling during high-flow periods (referred to as "trend" sampling). The network consisted of 26 stations during WY94, 29 stations during WY95 and 16 to 20 stations from WY96 to March 1999. Beginning in April 1999, the program was reduced to three point-source locations because the USGS was conducting a similar monitoring program. Beginning in 1994, IDEQ has also conducted monitoring to evaluate the effectiveness of remedial actions conducted in the Canyon Creek, Ninemile Creek, and Moon Creek Watersheds, and the Bunker Hill Superfund Site. These stations are typically sampled during high flow and low flow periods.

IDEQ sampled five long-term USGS stations: South Fork Coeur d'Alene River at Elizabeth Park (IDEQ Station ID SF-3) and Pinehurst (SF-1) and the main stem Coeur d'Alene River at Cataldo, Rose Lake, and Harrison. At the remaining stations, the stream stage was measured and discharge was estimated from a rating curve. The rating curve is a linear log-log relationship between stage and discharge developed by regression analysis of measured stage and discharge. Generally, 4 to 13 (21 at station CC-1) pairs of measured stage and discharge were used, depending on the station.

The November 1998 data were used in the evaluations of chemical mass loading in Parts 2, 3, and 4. Other mass loading estimates were not used in the evaluations because the discharges estimated from the rating curves appear to be in error. The apparent errors were most common when high-flow discharges were substantially greater than the range of measured discharges used to develop the rating curve. An estimate was inferred to be erroneous where discharges varied significantly without a pattern of increasing discharge from upstream to downstream stations, or where discharges estimated for tributary streams exceeded discharges in the South Fork Coeur d'Alene River. As a result, estimated discharges were not used if either of two criteria prevailed:

- The estimated discharge was substantially greater or less than the range of measured discharges used to develop the rating curve

- Discharges varied significantly without a pattern of increasing discharge from upstream to downstream stations.

5.3.2.4 USGS Data

The USGS has collected mass loading data in the Coeur d'Alene River basin during at least six sampling programs.

5.3.2.4.1 1991-92 Data. These data are presented in Woods and Beckwith (1997). Estimates of annual loads of total recoverable cadmium, lead, zinc, arsenic, and copper were developed for the two major tributaries to Coeur d'Alene Lake (the Coeur d'Alene River and the St. Joe River) near their confluences with the lake and for the Spokane River near Post Falls. The data were not used in the evaluations of mass loading due to limited geographic coverage of the data set.

5.3.2.4.2 1993-94 Data. These data are presented in Beckwith et al. (1997). Estimates of annual quantities of total recoverable cadmium, lead, and zinc transported at each of six stations were developed: two stations on the South Fork (Elizabeth Park and Pinehurst), one station on the North Fork (Enaville), and three stations on the main stem (Cataldo, Rose Lake, and Harrison). The data were not used in the evaluations of mass loading due to limited geographic coverage of the data set.

5.3.2.4.3 Water Year 1999 to Present Data. The USGS is currently collecting monthly mass loading data at 30 stations (24 prior to April 1999). Of the 30 stations, 3 are located in the North Fork Coeur d'Alene River drainage, 17 in the South Fork Coeur d'Alene River drainage (3 on Canyon Creek, 2 on Ninemile Creek, 5 on the South Fork, one each on Moon Creek, Placer Creek, Government Gulch, and Pine Creek), 3 on the main stem Coeur d'Alene River, 1 each on the St. Joe and St. Maries Rivers, 7 on the Spokane River, and 1 on Hangman Creek (Woods 2000b).

An additional 22 stations were monitored during the spring high flow between May 22 and May 25, 1999. The stations below Coeur d'Alene Lake and on the St. Joe River and St. Maries River were not monitored during this event. A total of 42 stations were monitored during the high flow event (Woods 2000c). Nine stations were monitored during both the ascending and descending limbs of the storm hydrograph. The event approximately corresponded to a two-year-recurrence-interval storm event (Woods 2000d).

These data were used in the evaluations of mass loading in Parts 2 through 6.

5.3.2.4.4 Groundwater Seepage Studies. The USGS studied groundwater/surface water interactions in three areas: the floodplain at Woodland Park, Osburn Flats, and the Smelterville and Kellogg Flats (USGS 1999; USGS 2000). As part of the study, mass loading for the corresponding stream reaches were measured. Data were collected in the Woodland Park area during two periods: September 17 through 19, 1999 and October 15 through 17, 1999. Data were collected in the Osburn Flats and the Smelterville and Kellogg flats areas during three periods: July 27 through 29, 1999, September 17 through 19, 1999, and October 15 through 17, 1999. The data were used in the evaluations of mass loading in Parts 2 and 3.

5.3.2.4.5 1996 and 1997 Adit and Seep Sampling. Mass loading data were collected at a total of 18 adits and seeps in August and November 1996 and June 1997 (Balistrieri et al. 1998). The total includes one location in the Big Creek Watershed, two locations in the Upper South Fork Watershed, five locations in the Mid-Gradient South Fork Watershed, three locations in the Canyon Creek Watershed, and seven locations in the Ninemile Creek Watershed. No concurrent collection of stream mass loading data was conducted; consequently, these data were not used in the calculation of mass loading within the main creek and river segments, but are included in the evaluation of loading from adits and seeps (Appendix J).

5.3.2.4.6 1996 and 1997 River Sampling. Three stations (North Fork at Enaville, South Fork at Elizabeth Park, and South Fork at Pinehurst) were sampled for total recoverable and dissolved cadmium, lead, and zinc during five events in November 1996 and March through June 1997. These data were not used in the calculation of mass loading due to the limited geographic coverage of the data set.

5.3.2.5 URS Data

URS collected mass loading data for the EPA RI for the Coeur d'Alene River basin during three events: Fall 1997 and Spring and Fall 1998.

5.3.2.5.1 Fall 1997 Data. Discharge/concentration data pairs were collected at 153 stream, adit, and seep locations in Fall 1997. Mass loading data were collected at 20 locations on Canyon Creek, 24 locations on Ninemile Creek, 78 locations on South Fork, 25 locations on Pine Creek, and 6 locations on other segments. The Fall 1997 data for the South Fork and its main tributaries (Canyon, Ninemile, and Pine Creeks) were collected over the 9 day period of November 4 to 13. Based on data at the USGS gaging station at Elizabeth Park (SF268), low flow for the season occurred on and around October 22 (87 cfs). By comparison, the daily average discharge values at this station for the November 4 to 13 period were 171 cfs on November 4 decreasing to 125 cfs on November 13.

The stations were sampled from downstream to upstream locations during a period of declining stream discharges (about a 25 percent decline, based on USGS Elizabeth Park data). This could result in higher estimated downstream contributions to loading relative to upstream contributions than actually exist.

These data were used in the evaluations of mass loading presented in Parts 2 and 3.

5.3.2.5.2 Spring 1998 Data. The Spring 1998 event was conducted during a non-steady, high discharge flow regime. Discharge/concentration data pairs were collected at 203 stream, adit, and seep locations in Spring 1998. Mass loading data were collected at 18 locations on Canyon Creek, 26 locations on Ninemile Creek, 79 locations on South Fork, 31 locations on Pine Creek, and 49 locations on other segments. The Spring 1998 data for the South Fork and its main tributaries were collected over the 5 day period of May 10 to 15. Based on data at the USGS gaging station at Elizabeth Park (SF268), high flow for the season occurred on and around May 4 (1360 cfs). By comparison, the daily average discharge values at this station for the period were 947 cfs on May 10 decreasing to 696 cfs on May 15.

The stations were sampled from downstream to upstream locations during a period of declining stream discharges (about a 25 percent decline, based on USGS Elizabeth Park data). This could result in higher estimated downstream contributions to loading relative to upstream contributions than actually exists.

These data were used in the evaluations of mass loading presented in Parts 2 and 3.

5.3.2.5.3 Fall 1998 Data. During the Fall 1998 program, URS collected mass loading data in Canyon Creek (25 locations), Ninemile Creek (13 locations), McFarren Gulch (5 locations), Pine Creek (one location), and the South Fork (one location). Canyon Creek was monitored during the period November 12 to 14, 1998 and Ninemile Creek was monitored on November 15 and December 6, 1998. Based on gaging data collected by the USGS, the discharge in Canyon Creek at Woodland Park decreased from about 20 cfs to about 17 cfs during the period November 12 to 14, 1998. Based on gaging data collected by the USGS, the discharge in the East Fork of Ninemile Creek near its confluence with the main stem was about 3 cfs and declining on November 15, 1998, and about 4 cfs and declining on December 6, 1998. The flow approximated steady-state, low-flow conditions during the sampling periods.

These data were used in the evaluations of mass loading presented in Parts 2 and 3.

5.3.2.6 Golder Data

5.3.2.6.1 1996 Data. Golder proposed to collect mass loading data from nine locations on the South Fork Coeur d'Alene River between Wallace and the Big Creek confluence during a single low-flow event in August 1996 (Golder 1996). The locations were previously sampled by MFG, and Golder retained the MFG location IDs: SF-135, 140, 150, 154, 160, 170, 180, 183, and 190. These data were not used in the evaluations of mass loading due to the limited geographic coverage of the data set.

5.3.2.6.2 1998 Data. In August and September of 1998, Golder conducted a two-phase study of mass loading on the South Fork downstream from its confluence with Pine Creek, the North Fork downstream from the USGS gaging station at Enaville, and the Main Stem downstream from the confluence of the North and South Forks to Cataldo (Golder 1998). Mass loading data were collected at 28 locations during Phase 1 and seven locations during Phase 2. The purpose of Phase 1 was to collect qualitative screening information with which to focus a more selective and detailed analysis during Phase 2. The mass loading data collected during Phase 1 were not computed from discharges measured at the sampling location, therefore, these data were not used in the calculation of surface water mass loading.

5.3.2.7 U.S. Bureau of Mines Data

The U.S. Bureau of Mines (BoM) conducted five sampling events in the Pine Creek Watershed, corresponding with the rising limb (March 1993), peak (June 1993), and falling limb (July 1993) of the stream hydrograph, a rain-on-snow event (January 1993), and the low-flow regime (August 1993). During all five sampling events, mass loading data at 18 stream sites were collected. During the peak and low-flow events, concentration data were also collected at adit discharges (16), seeps from mine dumps (8), stream sites below mine dumps (9), and springs (6) (McNary et al. 1995).

The BoM collected high flow mass loading data at seven locations in the Pine Creek Watershed during the period April 26 through May 9, 1993 (SAIC 1993). Mass loading data were also collected at two to seven locations in the Moon Creek Watershed during five sampling events between April 6 and December 7, 1993 (Paulson 1996). These data were not used in the evaluation of mass loading due to the limited geographic coverage of the data sets.

5.3.2.8 U.S. Forest Service Data

The USFS collected mass loading data at 18 adit drainages located on USFS land in July/August 1997, including 1 in the Canyon Creek Watershed, 4 in the Big Creek Watershed, 7 in the Upper South Fork Watershed, and 6 in the Midgradient South Fork Watershed (Kauffman et al. 1999). The data were not used in the calculation of surface water mass loading within the main creek and river segments, but are included in the evaluation of loading from adits (Appendix J).

5.3.2.9 U.S. Bureau of Land Management Data

The BLM collected mass loading data at four adits in the Pine Creek Watershed in July 1994 (CCJM 1998; Ridolfi 1999). In addition, three samples were collected at one adit location from August 1997 to November 1998. These data were not used in the evaluation of mass loading within the main creek channel, but are included in the evaluation of adit loading (Appendix J).

5.3.2.10 Hecla and Asarco Data

MFG collected mass loading data for Hecla and the SVNRT at 11 adit drainages in 1991: 4 in the Canyon Creek Watershed and 7 in the South Fork Coeur d'Alene River Watershed (Gearheart et al. 1999).

Asarco collected mass loading data for the Gem No. 3 portal for 13 sampling events between July 1997 and July 1998 (Gearheart et al. 1999). The data were not used in the calculation of surface water mass loading within the main creek channel, but are included in the evaluation of adit loading (Appendix J).

5.3.2.11 Ecology and Environment Data

In October 1994, Ecology and Environment, Inc., collected samples from five reaches in the Coeur d'Alene basin: South Fork from Pine Creek to the North Fork (24 locations), Pine Creek at Matchless Gulch (10 locations), South Fork from Terror Gulch to the Evolution Bridge (9 locations), South Fork from Wallace to Silverton (13 locations), and the Tamarack mine area on Canyon Creek (10 locations) (E&E 1995).

Discharge was not measured following USGS procedures. Rather, a single stream velocity measurement was taken near the center of the stream at its greatest depth, and a single depth measurement was taken (location not documented). The calculated discharge values vary widely over relatively short distances. Metals concentrations in surface water samples were measured using a field technique, anodic stripping voltammetry, with limited laboratory verification. Due to the uncertainty in discharge results, the data were not used in the evaluation of mass loading.

5.4 FATE AND TRANSPORT EVALUATION

A conceptual site model describing fate and transport in the Coeur d'Alene basin was presented in Sections 2 and 3.3. The model identified important fate and transport mechanisms, pathways and receptors. Given the complexity and size of the basin, the importance of any mechanisms may vary with location within the basin. For this reason, discussion of the conceptual model was divided into two parts: the Coeur d'Alene River, Spokane River and watersheds and Coeur d'Alene Lake. Fate and transport mechanisms operable in the Lateral Lakes may be different from those of importance in Coeur d'Alene Lake because of differences in scale, depth, biological productivity, and muted inflow dynamics.

This section presents descriptions of fate and transport mechanisms of importance in the Coeur d'Alene and Spokane River basins and Coeur d'Alene Lake, followed by methods used in this RI report to quantify fate and transport in the study area. A probabilistic model was used to help quantify fate and transport in CSM Units 1, 2, 3, and 5. More standard descriptive methods were used to estimate fate and transport in Coeur d'Alene Lake (CSM Unit 4).

5.4.1 Summary of Important Fate and Transport Mechanisms

Fate and transport mechanisms deemed to be of major importance to the Coeur d'Alene River basin are summarized in this section. For details on the mechanisms themselves and additional results, including equations, refer to Sections 3.3 (on regional geochemistry), 3.4 (on regional hydrogeology), and 3.5 (on regional hydrology). For example, fate and transport mechanisms of importance are discussed qualitatively and quantitatively in Section 3.3 (regional geochemistry). In order to avoid unnecessary redundancy, only a brief summary of fate and transport mechanisms is presented here. These mechanisms are also discussed in sections on the individual watersheds (RI Parts 2 through 6).

Fate and transport mechanisms presented below were implicitly considered in the probabilistic model (Section 5.4.2). That is, the model subsumes fate and transport mechanisms but no actual mechanistic equations are explicitly included. Furthermore, fate and transport mechanisms were used, as required, to interpret model results. However, these mechanisms were not considered explicitly in the model because of the complexities and uncertainties involved. The probabilistic model is a practical means of addressing this complexity and uncertainty and, moreover, will provide a useful tool for assessing post-remediation impacts in the FS.

5.4.1.1 Impact of Flow Events on Metal Transport

Flow events from 1991 through 1999 were evaluated to help understand how flow events impact fate and transport by affecting the concentrations of dissolved and total metals in solution. In addition to further discussion in Section 3.3 (on regional geochemistry), the impact of flow events is addressed in Section 5.3 (on mass loading).

5.4.1.2 Impact of pH on Metal Fate and Transport

Plots were made of surface water and groundwater pH values across the basin. These plots were compared to geologic maps to identify ore bodies and formations associated with particular ranges of pH values. Furthermore, total dissolved metal concentrations (sum of dissolved Pb, Zn, Cd, Cu, Co, and Ni concentrations) were plotted versus pH and the ratio of reacting pyrite to reacting carbonate. Additionally, reactions were written for minerals found throughout the basin to evaluate the acid- or base-generating capability of each mineral. Finally, based on a

knowledge of the reactions occurring, an equation was written to estimate the acid- or base-generating potential of a specific location containing a variety of ores and minerals.

5.4.1.3 Effect of Water Types on Metal Concentrations

Graphical methods, specifically Piper diagrams, were used to help interpret water chemistry involving mixing. Water types along the Main Stem, South Fork, and tributaries were evaluated using Piper diagrams during low- and high-flow sampling events.

5.4.1.4 Effect of Iron Content on Metal Concentrations

Correlation coefficients (r-values) were calculated to measure the linear relationship between total iron and total concentrations of lead, zinc, and cadmium. Dissolved and particulate metal concentrations were correlated with total iron concentrations for low- and high-flow events.

5.4.1.5 Adsorption Mechanisms

Empirical (distribution coefficient) and theoretical (surface complexation approach) methods were used to predict the partitioning of metals between the dissolved phase and suspended particulates.

Collocated water and soils samples from throughout the Coeur d'Alene basin were identified. Metal and soil concentrations of lead, zinc, and cadmium for these collocated samples were used to compute distribution coefficients (K_d). Distribution coefficients were used, in conjunction with soil physical properties, to compute a retardation factor. The aqueous pore-water velocity was then divided by the retardation factor (Rf) for a given constituent to estimate the migration velocity of that constituent. Whereas the K_d is an indication of the ratio of the constituent concentration on the soil to the concentration in solution, the retardation factor provides an estimate of the ratio of the absolute mass of constituent on the soil to the absolute mass in solution.

A surface complexation model was used to predict metal partitioning between the dissolved and particulate phases. Predictions obtained from the surface complexation model were compared to laboratory data. Surface complexation models have the potential to accurately predict variations in oxide acid/base properties as a function of ionic strength and pH. Specifically, the MIT Diffuse-Layer Model was used to model adsorption in the surface waters of the Coeur d'Alene basin because it fits the data as well as other surface complexation models (e.g., Constant Capacitance and Triple-Layer Models), while eliminating multiple planes of adsorption and multiple fitting parameters. Data for low- and high-flow events were modeled.

5.4.1.6 Dissolution/Precipitation Mechanisms

Dissolution/precipitation reactions using solid phases and minerals expected to precipitate or dissolve rapidly enough to control the concentrations of certain of their elemental components (e.g., lead, zinc, and cadmium) were used to estimate fate and transport.

The ion-speciation-solubility portions of the MINTEQA2 geochemical computer code were used to model selected aqueous solutions. Solubility calculations were performed to evaluate if a mineral was oversaturated, undersaturated, or at equilibrium with the solution.

In addition to identifying the saturation status of minerals and solid phases, minerals and solid phases of particular interest were assumed to be in infinite supply. By assuming these minerals and solid phases were in infinite supply, the concentrations of certain of their components in basin water samples were controlled. Furthermore, the pH and redox status were varied on water samples of interest to evaluate solids phases and minerals they would successively form and dissolve as these parameters changed. The geochemical computer code (MINTEQA2) was used to perform these calculations on surface waters and pore waters in lakes throughout the basin.

5.4.1.7 Hydrology

This section provides an overview of important parameters and mechanisms that impact hydrologic fate and transport. Additional details on the various mechanisms and parameters are found in Section 3.5.

Precipitation in the form of rain or snow provides the ultimate source of water in the Coeur d'Alene basin. This water flows off hillslopes, seeps into the soil, is evaporated, or used by vegetation for growth. When water flows overland and through channels, sediment and dissolved minerals can become incorporated into the flow. Once entrained in the flow, surface water flow is the major transport mechanism of moving sediments (including fine-grained, primary and secondary minerals – enriched waste rock, tailings, and soils) and dissolved metals. In addition to incorporating sediment and dissolved constituents, surface water can remobilize sediment stored in the banks and channel bottom by scouring and eroding riverbanks. The watershed extends from the Idaho-Montana border to the mouth of the Main Stem at Coeur d'Alene Lake. This entire area provides surface water, sediment, and dissolved constituents to the system.

The form of precipitation greatly affects the surface water hydrology of the Coeur d'Alene watershed. Precipitation in the mountainous areas in the upper basin predominately occurs as snow during the fall and winter months. This water is temporarily stored as snow pack and does not run off into the channel system directly. Rainfall and warmer temperatures in spring and early summer months melt the snow and cause the stored water to discharge to the tributary streams. Generally, the largest stream flow discharges each year occur during the spring and early summer. This phenomenon is observable throughout the watershed but is most pronounced in the mountainous tributary channels. At lower elevations, downstream in the watershed, more precipitation falls as rain and runs off directly into the channels. This direct runoff generally produces intermediate discharges, still less than the spring and early summer snowmelt discharges. The magnitude of these intermediate discharges as a percentage of peak annual discharge is larger than for the same comparison of the mountainous tributary channels. This comparison underscores the importance of snow storage in the mountainous tributary channels.

Although, the largest annual discharges generally occur in the spring and summer due to snow melt, very large discharges can occur during the winter. These events are typically caused by large amounts of snowfall throughout the basin followed by temperatures that are more moderate and rain. Rain on snow is very efficient at melting the snow and producing large discharges in the channels. Discharge and backwater effects in the lower Coeur d'Alene River are influenced by the elevation of Coeur d'Alene Lake as controlled by the Post Falls Dam. Because the Lateral Lakes, adjacent to the Lower Coeur d'Alene River are directly connected to the Coeur d'Alene River by dredged channels, water level changes in the river directly influence the water levels of the lakes. At higher river discharges, the water surface in the river is such that water flows into the lakes, at lower river discharges water flows from the lakes to the river. This change in hydrologic regime occurs at a river discharge of approximately 3,000 cubic feet per second (cfs).

In addition to stream discharge varying through a given year, discharges vary from year to year depending on rainfall, snow pack, and temperature. These varying discharges are often described in terms of recurrence intervals or exceedance probability. For purposes of this discussion, the term recurrence intervals will be used. Recurrence intervals are the average number of years between annual peak events equaling or exceeding a given magnitude. The USGS has maintained a system of stream flow gages in the Coeur d'Alene watershed for a period of years. Some of these gages have a period of record dating from 1952 to the present; others have shorter periods of record. These historical data were used to calculate the discharge of specified recurrence intervals at stations where sufficient historical data were available. This information is useful in determining the size and required strength of remediation measures and for other flood planning purposes. The calculations were based on the Water Resources Council, Bulletin 17-B, which used a log transformation of the flood data (log-Pearson Type III). These results are presented in Section 2.3 of the individual watershed reports.

In addition to the historical peak data, FEMA Flood Insurance Studies are available for the Coeur d'Alene River (published in 1979). These studies predict recurrence intervals throughout the basin using empirical relationships developed for the watershed. With 20 additional years of stream flow data at some locations, these studies may be dated. However, these studies may be useful in areas where existing data is unavailable for frequency analyses. These results are presented in Section 2.3 of the individual watershed reports.

Flow discharge information has been collected by numerous consultants and agencies for use in mass loading calculations. Although these data are usually not continuous and might have been collected at numerous sites, it can be used to gain additional insight into the surface water hydrologic regime of the sampling location. These data were used as comparison to measured stream flow at nearby locations to determine the reliability of each data source.

The USGS installed several additional gages in the Coeur d'Alene River watershed for water year 1999. Water year 1999 ran from October 1, 1998, to September 30, 1999. These data were compared to precipitation and temperature data for water year 1999 and long-term climatic data for understanding of the overall climatic and hydrologic conditions experienced during water year 1999. These comparisons emphasized the relationships between the precipitation as snowfall and the overall hydrologic patterns found throughout the Coeur d'Alene watershed.

In summary, the overall drainage area at the USGS Harrison gage station, approximately 2.5 miles upstream of the mouth, is approximately 1,475 square miles. Precipitation occurring within this area is temporarily stored, used by plants and animals, evaporates, or runs off into streams, creeks and rivers. Most of the water that is temporarily stored eventually runs off or is discharged to streams. The flowing water in these streams is capable of transporting sediment and dissolved minerals throughout the system. The water flows from the headwaters at the Idaho-Montana border to the mouth at Coeur d'Alene Lake. Temporary storage and retardation of dissolved and particulate metals and sediments occur throughout the basin.

5.4.1.8 Erosion and Sediment Transport

5.4.1.8.1 Overview. This section provides an overview of the physical processes contributing to sediment erosion and transport. The physical processes of rain falling on soil, runoff from snowmelt or precipitation, channel bank and bed erosion, or mass movements incorporate sediment into streams of water. Water in streams transports, deposits, and sorts the delivered sediment based on the stream energy, discharge, and size and quantity of sediment.

Sediment transport by streams is a natural process; however, human activities such as mining, logging, road building, urbanization, or land clearing can significantly increase the rate at which sediment transport occurs. For instance, land clearing exposes soil and rock that might be subject to erosion. Further, this disturbance might decrease the amount of water storage in the soil, increasing runoff rates and providing additional surface water and energy for sediment transport.

The rate at which sediment passes through a cross section of a stream system is referred to as the sediment yield. This annual sediment yield can be broken down into components that describe the method of transport: suspended load and bed load. Suspended load consists of particles small and light enough to be carried downstream in suspension by shear and eddy forces in the water column. Bed load consists of larger and heavier particles that move downstream by rolling, sliding, or bouncing on the channel bed. Accordingly, suspended sediments remain in suspension and move with the water while bedload sediments move along the channel bottom at a lower velocity than the water.

All sediment motion downstream is dictated by the shear and gravitational forces acting at a given time and place within the channel. For sediment transport purposes, gravitational forces are essentially constant. Shear forces, however, are dynamic through space and time and are dependent upon the location, depth of water, and slope of the water surface. Sediment transport occurs at even the smallest of stream channel discharge, but the majority of movement occurs during moderate to high discharge when shear forces are greatest.

5.4.1.8.2 Methodology. The methodology used to evaluate erosion and sediment transport is presented in this section. One year, water year 1999, of sediment transport gaging data is available for eight stations in the Coeur d'Alene River watershed from the USGS. Each of these sediment transport stations is associated with a USGS discharge gaging station. For each station, suspended sediment samples were collected six to eight times throughout the year. Bed load sediment was sampled four to six times at each of the stations. The suspended and bed load sampling events were completed over a range of stream discharges to establish a rating curve relating sediment discharge to stream discharge. In addition, sampling was completed on both the rising and falling limbs of high-water events to examine the transport during these differing conditions. Instantaneous stream discharge was recorded at the time of sampling. Rating curves were developed by plotting measured instantaneous discharge versus suspended sediment concentration on a log-log plot and fitting a power function to the data. An example rating curve for suspended sediment at Canyon Creek is shown in Figure 5.4-1. Similar rating curves for bed load were also calculated on log-log plots. The rating curves for the suspended load and bed load were integrated with the mean daily discharges measured at the associated USGS gage to achieve a daily sediment discharge for each sediment type. The date versus daily sediment discharge and cumulative sediment discharge for the fines, sand, and bed load were plotted to identify the significant periods of sediment discharge and correlate this to high flow and periods of snowmelt. Examples of these plots are shown in Figures 5.4-2 and 5.4-3. In addition to producing these figures from the daily sediment discharge calculations, sediment yield and total annual sediment discharge were calculated by summing the daily sediment discharge for the year to obtain annual sediment discharge and dividing by drainage area to obtain sediment yield. For example, approximately 1,350 tons of sediment passed the Canyon Creek gage station located at Wallace in 1999. Expressed as a sediment yield for the 21.9 square mile basin, this is 62 tons per square mile per year.

The daily sediment discharge calculation was further refined to establish partitions in discharges where the majority of sediment and size classes are transported. For each daily sediment discharge calculation, fines, sand, and bed load, the percentages of the total annual sediment discharge passing at the measured stream discharges were plotted in Cartesian coordinates. The resulting figures may indicate characteristic discharges when increases in sediment discharges occur. An example for Canyon Creek is shown in Figure 5.4-4 where the percent of the total annual sediment discharged is plotted versus stream discharge. As seen in Figure 5.4-4 for Canyon Creek, approximately 43 percent of the sand fraction and 60 percent of the fines occurs at stream discharges greater than 245 cfs.

Stream classifications can provide insight into channel conditions and broad level channel morphologies. Although any classification system is limited, generalizations concerning transport characteristics of individual channel types can be made. These generalizations have limitations; however, value can be achieved by realizing these limitations and using the information in a general rather than a specific manner. The Rosgen Level 1 classification methodology was used to identify reaches of different stream types. Topographic map and limited aerial photograph interpretation were completed for the Rosgen Level 1 classification for each basin. In general, this information can be viewed as locating channel reaches where distinct processes or phenomena are likely to be discovered. These processes include channel braiding, aggrading, degrading, erosion, and deposition. Figures were used to present a more detailed aerial photograph review as discussed in the following paragraphs.

Detailed review of aerial photographs from 1983, 1984, 1991, and 1998 were completed to identify distinct areas in which erosion, channel migration, deposition, and aggregation were occurring or might be likely to occur. Photographs were reviewed and areas of channel movement, erosion, deposition, or other notable features were identified and located on a stationing system established for each basin. The stationing system for Canyon Creek Segment 04 is indicated on Figures 5.4-5 and 5.4-6. Morphology changes or changes in alignment were noted during the review, and channel reaches exhibiting similar morphology were grouped and described in detail. In addition, source areas including road cuts, gravel roads, rock piles, and mine and mill workings were identified that constitute probable sediment sources for the river system. These observations were presented on topographic maps and in written text to provide additional information concerning the terrain surrounding each source.

For the lower Coeur d'Alene River where the channel slope is very low, channel migration has not occurred over the time frame of mining activities, but channel widening is occurring. Detailed measurements of river bank erosion were completed using digital calipers; aerial photography from 1958, 1975, 1983, 1984, 1991, and 1998 was reviewed to estimate long-term channel widening.

5.4.2 Fate and Transport Model

Understanding the movement, or fate and transport, of metals from source areas to other parts of the basin is a key piece of both the remedial investigation (RI) and the feasibility study (FS). To understand a large natural system like the Coeur d'Alene River Basin, it is important to answer the what, where, and how questions of metal movement.

What is the best way to describe metal movement and deal with the large variation in the natural world and the data? A mathematical model, called a *probabilistic model*, was selected as the best tool to handle the complex issues involved. For selected stream monitoring points in the basin (e.g., the mouth of Canyon Creek, Pinehurst, and Harrison), the model is used to:

- Predict metal concentrations in the stream
- Predict metal loading[1] in the stream (i.e., how much metal is flowing in the stream)
- Quantify the uncertainty associated with the predictions in a consistent and coherent manner

The portion of the model used for the RI is limited to current conditions in the basin. In the FS, the complete model is used to make quantitative estimates of the potential remedial performance associated with each remedial alternative. Because it helps quantify the certainty that a remedial action will actually result in meeting cleanup goals, the model can be used in the remedy selection process to help decision-makers select and prioritize cleanup efforts.

This section provides an introduction to the model as used in the RI for metal fate and transport. Metal fate and transport and natural variability are introduced first. This is followed by a discussion of the model with an emphasis on the lognormal distributions that are used in the model. Model results for the RI are presented in Sections 5 of Parts 2 though 6. Model development details are presented in the technical memorandum *Probabilistic Analysis of Post-Remediation Metal Loading* (URS 2001).

[1]Loading is the quantity of metal transported in stream flow (usually measured as pounds of metal per day, #/d). Loading is calculated by multiplying the stream flow (usually measured as cubic feet of flow per second, cfs) and the metal concentration in the stream flow (usually measured as parts per billion, ppb).

5.4.2.1 Metal Fate and Transport

The focus of metal fate and transport in the probabilistic model is the movement of metals by water, both surface water and groundwater. This section presents a simple overview of metal transport by water in the basin.

Metal transport in the basin is complex. Metal transport begins with the metal sources in the basin that have been created by historical mining activities. Scattered throughout the upper basin, primary metal sources include tailings and waste rock piles, tailings buried in river floodplains, and discharges from mine adits. Secondary sources include tailings-impacted river sediments in the upper basin and contaminated sediments in floodplains, wetlands, and lateral lakes of the lower basin. Throughout the basin, these sources vary dramatically in their size, metal concentrations, and degree to which they act as metal sources.

Transport by flowing water is the primary way that metals are moving in the basin. Metal transport begins when water contacts a metal source, and the metals become dissolved or suspended in the water. Water contacts metal sources in many ways. Examples include streams flowing over exposed sources in stream channels; groundwater flowing through buried sources (e.g., sources that are buried in river floodplains); and surface water runoff from rainfall and snowmelt that flows over or into waste piles.

The dissolution or suspension of metals into water occurs to varying extents, depending on geochemical, hydrologic, and geologic conditions. Also, under certain conditions, metals that are already dissolved or suspended in water can be removed from the water by natural physical, chemical, and biological processes. The quantity of metal in water that is available for transport depends on the net difference between the metals entering the water and the metals leaving the water. This net difference varies from location to location and over time, depending on the natural variability in the conditions that control the various processes. Metals that remain in surface water or groundwater are transported with that water.

As water flows downgradient from the higher areas of the basin, either as groundwater or surface water, it mixes with other waters. Mixing occurs both as different groundwater flows merge or seep into surface water, and as surface water steams combine into large streams. The degree of mixing and the quantities of water involved depend on geologic and hydrologic conditions that vary over time and location. Sooner or later, any water carrying metals will enter the major surface water streams of the basin, and be further transported by stream flow down the basin.

5.4.2.1.2 Natural Variability. All these sources of natural variability in the basin, which include:

- Variability in metal sources
- Variability in the degrees to which metals enter and remain in water
- Variability in the quantities of flowing water
- Variability in the mixing processes that occur as waters flow downgradient

cause natural variability in the transport of metals in the basin. In particular, stream flows and the transported metal concentrations and loadings generally show great natural variability. This natural variability is dynamic. It occurs both by location along the stream and over time at any given stream location.

From the standpoint of predicting metal transport, natural variability is a fundamental consequence of uncertainty about the natural system. It is the result of not having complete information on all the processes, conditions, factors, and parameters that determine actual stream flows and metal concentrations and loadings throughout the basin. Furthermore, complete information would include knowing how these determinates will change over time. Such complete knowledge is not attainable in any practical sense.

Natural variability creates uncertainty. Because of natural variability, stream flows and metal concentrations and loadings are always uncertain to some extent. Uncertainty due to natural variability can be minimized at any specific location and time by taking measurements of stream flows and metal concentrations and (computing) loads. However, as time passes, stream flow and metal concentration and loading at that point will change to an uncertain extent due to natural variability. Therefore, except at the time measurements are taken, stream flows and metal concentrations and loadings are uncertain.

Uncertainty due to natural variability makes *accurate* predictions of stream flows and metal concentrations and loadings impossible, except in a *probabilistic* sense, as discussed in the following section. Therefore, to deal with uncertainty due to natural variability, a probabilistic model is used to make predictions of stream flows and metal concentrations and loadings for the basin. The following section provides an overview of the model.

5.4.2.2 Probabilistic Model

As discussed above, motivation for using the probabilistic model stems from the inherent complexity and uncertainty associated with stream flows and metal concentrations and mass loadings in the basin. Probabilities, based on the mathematics and physics of "chance," are used to quantify natural variability and uncertainty.

The probabilistic model is based on the fact that effects of natural variability result in characteristic patterns that can be described, or *modeled*, and analyzed mathematically. Specifically, the natural variability in stream flows and transported metal concentrations and loadings follows a pattern called a *lognormal probability distribution*, or simply, a *lognormal distribution*. The lognormal distribution is a pattern commonly found in the natural world. The theoretical basis as to why stream flows and metal concentrations and loadings should follow lognormal distributions comes from the physics and mathematics of probability ("laws of chance") and random processes, including the Theory of Successive Random Dilutions, the Law of Proportional Effect, and the Central Limit Theorem.

Most important, lognormal distributions fit the available measurements of stream flows and metal concentrations and loadings in the basin. The fits are good approximations that reflect the fact that no theoretical distribution ever exactly fits real world data, which are of limited quantity and subject to measurement errors.

What gives the lognormal distributions practical value is their quantification of the accuracy of specific estimates or predictions of flow and metal concentrations and loadings within the basin. However, before discussing this, it may be helpful to make lognormal distributions a bit more concrete, which is the purpose of the following illustration and example.

5.4.2.2.1 Illustration of Lognormal Distributions. Figure 5.4-7 is an illustration depicting the repeated measurement over time of stream flows and metal concentrations and loadings at a sampling point. The sampling point is located downstream from various metal sources that load the stream system over a geographic region, which includes loadings to tributaries and groundwater. The idealized depiction in Figure 5.4-7 is meant to represent a realistic situation with multiple metal sources and water transport processes that naturally vary in response to the many conditions that determine stream flows and metal concentrations and loadings.

The situation in Figure 5.4-7 assumes a given sampling location where repeated measurements of stream flow and metal concentration (from which loading is computed) are made. The measurements would occur over a suitable period of time, say twice a month over several years. To be specific, assume that, over the sampling time period, a total of 100 measurements of stream flow and metal concentration are made. Because of natural variability, these 100 measurements will have a distribution of values, ranging from relatively low to relatively high. There will be a different distribution for flow, for metal concentration, and for metal loading.

To continue the illustration, take the flow measurements and imagine making a *histogram* of the results, as illustrated in Figure 5.4-7; that is:

- Divide the range of flow measurements into several groupings of increasing flow, from low values to high values
- Count the number of samples having flow results in each grouping
- Graph the number of samples in each grouping to make a histogram

Figure 5.4-7 shows a typical histogram for stream flows. The histogram follows a lognormal distribution. Relatively few flows occur in the first grouping, reflecting the observation that the very lowest flows are relatively uncommon. The most common flows occur in the second grouping, reflecting typical "low flow" (summer) conditions. The most common flows have the maximum[2] number of samples. After the maximum, the number of samples decreases with the increasing flow.

The number of samples "tails off" at the higher flows, to the right on the histogram. This characteristic is known as a "skew" in the higher-flow "tail" of the distribution, or simply "skew." A distribution with low skew is more symmetrical than one with high skew. The degree of skew indicates the degree of natural variability: more skew means more natural variability, and vice versa.

The curve superimposed over the histogram show the equivalent lognormal distribution that would result from a large number of measurements and using very narrow histogram groupings. That is, very narrow histogram groupings and a very large number of measurements would result in a "continuous" distribution.

Histograms for the metal concentrations and metal loadings would also result in lognormal distributions, as illustrated in Figure 5.4-7. Note that all values are positive, since there can be no negative flows, concentrations, or loadings. The restriction to positive values and a skewing of higher values in the tail of the distributions is characteristic of lognormal distributions.

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[2]The maximum number of samples in the distribution should not be confused with "peak flow," which occurs during flood events. Peak flows would be represented in the tail of the flow distribution, in the far right of the histogram.

Figure 5.4-7 is an illustrative example based on hypothetical measurements. As will be discussed next, Figures 5.4-8 through 5.4-10 shows lognormal results from actual, historical measurements of stream flows and metal concentrations and loading.

5.4.2.2.2 Example of Historical (Actual) Measurements. Historical measurements are important because they provide a database for predicting current and future values. Specifically, in the RI/FS, lognormal distributions are estimated from historical measurements of stream flow and metal concentrations and loadings using statistical methods based on linear regression. Results are presented in Sections 5 of Parts 2 through 6.

To help make these lognormal distributions more concrete, Figures 5.4-8 through 5.4-10 shows the histograms from results of historical measurements at the USGS sampling station at Pinehurst (SF271) on the SFCDR. The historical measurements include stream flow (Figure 5.4-8), dissolved zinc concentrations (Figure 5.4-9), and dissolved zinc loadings (Figure 5.4-10). Approximately 100 measurements were taken periodically between 1991 and 1999.

Two sets of histograms are shown in Figures 5.4-8 through 5.4-10. The dark histograms are for the historical measurements. The open histograms are for the theoretical lognormal distributions that were estimated from the measurements using statistical techniques.

As can be seen, there is a very high correspondence between the measurement histograms and the lognormal histograms. The deviations that do occur mirror the fact that no theoretical distribution ever exactly fits real world data, which are always subject to limitations. In particular, the historical measurements, like all measurements, suffer from measurement errors. In addition, the limited number of available historical measurements subjects the lognormal distributions to a degree of statistical uncertainty. It is very likely that the correspondence between the measurements and the lognormal distribution would increase further, particularly in the skewed tails of the distribution, if additional measurements, taken with minimal error, were available.

Importantly, similarly high correspondence between historical measurements of flow and metal concentration and loading and lognormal distributions have been found at all other sampling stations. This consistently high degree of correspondence helps provide practical confirmation that the *true* values of current stream flow and metal concentration and loading can be adequately *modeled*, or approximated, as lognormal distributions. Nevertheless, like the historical measurements on which they are based, theoretical distributions are only approximations of future values, which are always inherently uncertain to some degree.

Figure 5.4-11 shows the estimated lognormal distribution for zinc loads using a histogram with 100 groupings (the skewed curve in the figure). Compared to the nine groupings used in Figures 5.4-8 through 5.4-10, these 100 groupings are narrow enough to indicate the equivalent "continuous" distribution. The continuous distribution is what the lognormal distribution predicts would result if a very large number of measurements (e.g., thousands) were made (and analyzed using the same100 histogram groupings used in Figure 5.4-11).

The shape of the continuous distribution provides a "picture" of the natural variability. A wide or highly skewed distribution means high natural variability. A narrow or symmetric distribution means low natural variability. The continuous distribution reflects the net effect from all-upstream metal sources and fate and transport processes. In the case of Figure 5.4-11, the continuous distribution reflects that net effect for zinc loading in the SFCDR at Pinehurst.

Cumulative Probabilities. The cumulative probabilities are also graphed in Figure 5.4-11. For any zinc given load, the cumulative probability is the sum of the probabilities from all the histogram groupings less than or equal to the given load. Or simply, the cumulative probability is the sum of the probabilities of all loads less than or equal to a given load. The cumulative probabilities start at 0 percent for zero load and increase with increasing load to an asymptotic maximum of 100 percent at the highest zinc loads.

It is the cumulative probabilities that are the key to the model. The cumulative probability for a given load is interpreted as the estimated probability (or "chance") that the true load (at any given time or over time) is less than the given load. Equivalently, the cumulative probability is the probability that the given load exceeds the true load. One minus the cumulative probability is an estimate of the probability that the true load exceeds the given load. Cumulative probabilities for stream flow and zinc concentration would be interpreted in the same way. Figure 5.4-11 provides some specific examples of probabilistic estimates using cumulative probabilities.

The cumulative probabilities from Figure 5.4-11 can be used to estimate the zinc *loading* in the SFCDR at Pinehurst having a given probability (or chance) of *not being* exceeded at any given time or over time. Figure 5.4-11, shows, for example, an estimated:

- 25 percent probability that the true load is 1,700 pounds per day or less
- 50 percent probability that the true load is 2,400 pounds per day or less
- 90 percent probability that the true load is 4,900 pounds per day or less

Similar estimates could be made of the true zinc loading having a given probability (or chance) of *being* exceeded at any given time or over time.

The cumulative probabilities can also be used to estimate the *probability* (or chance) that a given zinc loading is *below* (or not exceeded by) the true loading, at any given time or over time. Figure 5.4-11, shows, for example, that a:

- 2,000 pounds-per-day load has a 36 percent probability of not being exceeded
- 3,000 pounds-per-day load has a 65 percent probability of not being exceeded
- 7,000 pounds-per-day load has an 97 percent probability of not being exceeded

In addition, the cumulative probabilities can be used to estimate the probability (or chance) that any given zinc loading is *above* (or exceeded by) the true loading, at any given time or over time. Figure 5.4-11, shows, for example, that a:

- 10,000 pounds-per-day load has a 1 percent probability of being exceeded
- 5,000 pounds-per-day load has a 9 percent probability of being exceeded
- 1,000 pounds-per-day load has an 95 percent probability of being exceeded

Similar estimates for stream flow and concentrations could be made from the cumulative probabilities for those variables.

5.4.2.2.3 Use of the Lognormal Distributions. To help control data limitations, only those sampling stations having an adequate number of measurements are modeled probabilistically. Specific sampling data used for each modeled location are included in Appendix C. For those stations, statistical methods are used to fit lognormal distributions to the available historical measurements of stream flow and metal concentrations and loadings. The resulting lognormal distributions represent estimates of current conditions, based on available data. At each sampling station, the lognormal distributions quantify:

- The natural variability associated with stream flow and metal concentrations and loading

- The net effect from all upstream metal sources and fate and transport processes, which result in the metal concentrations and loadings at the sampling location

- The metal concentration or loading having a given probability of not being (or being) exceeded by the true value

- The probability that any specific concentration or loading is higher or lower than the "true" value

It is in FS and subsequent remedy selection that the model will be most useful. For the FS, the model is used to make quantitative estimates of each alternative's potential remedial performance. For each remedial alternative, the potential *post-remediation* metal concentrations and loadings are estimated for key stream monitoring locations in the basin. These estimates are compared to ambient water quality criteria (AWQC) and total maximum daily loads (TMDLs) and evaluated as part of the CERCLA remedial action evaluation criteria. The model is thus vital to helping evaluate the effectiveness of potential cleanup remedies.

The model can also be used in remedy selection. Because it helps quantify the certainty that a remedial action will actually result in meeting cleanup goals such as AWQC and TMDLs, the model can help decision-makers select a remedy. In addition, the model provides a risk management tool for making remedial decisions under conditions of uncertainty that can be used to estimate the confidence associated with those decisions.

Fate and Transport Mechanisms of Importance in Coeur d'Alene Lake and the Lateral Lakes

In the previous section (Section 5.4.2), the methodology used to describe fate and transport mechanisms in the Coeur d'Alene and Spokane River basins was presented (CSM Units 1, 2, 3, and 5). In this section, the methodologies used to portray fate and transport in Coeur d'Alene Lake are discussed.

5.4.3.1 Mass Balance Calculations

Metal mass balance was calculated with available data using fundamental mass balance equations. The mass balance calculations included dissolved, particulate, and total metal concentrations. Mass balance computations also were conducted on the sediment load. These computations were used in conjunction with known time markers (e.g., ^{137}Cs deposition, history of mining activities, Mt. St. Helens eruption, etc.) to estimate the current and historical deposition rate.

The USGS examined data for calendar years 1991 and 1992 and water year 1999 and computed the inflow and outflow loads and the residual remaining in the CdA Lake. Load calculation methods and results are described in Woods and Beckwith (1997) and Woods (2000). The residual load was calculated as the difference between inflow and outflow at the sampling location situated on the Spokane River near Post Falls, Idaho. Metal and nutrient masses in CdA

Lake were calculated assuming a lake volume of 2.8 billion cubic meters (Woods and Berenbrock, 1994).

The inflow of WWR lead into the lake in 1991 was substantially larger than in 1992, largely because of enhanced erosion and transport of sediment-associated lead due to higher discharges. Approximately 85 percent of the 1991 inflow of WWR lead was retained in the lake; retention dropped to approximately 71 percent in 1992. Substantial deposition in the lake of WWR lead in 1991 and 1992 is indicated by the large excess of residual WWR lead versus the mass of lead in the lake.

5.4.3.2 Sediment Deposition Rate

Sedimentation rates in CdA Lake at 12 locations were calculated by Woods (2000). The overall trend in sedimentation rate with increasing distance from the mouth of CdA Lake was one of decrease; the smallest sedimentation rate was measured for core 13 in the central portion of the lake's northern end. If one uses 1910 as the date of onset of sedimentation of trace-element-enriched sediments, then the average lake-wide sedimentation rate is 0.44 cm/year based on an enriched sediment layer about 35 cm thick. Calculated sedimentation rates for the banded zones are based on 80 years of deposition, from 1910 to 1990, and ranged from 0.21 to 1.5 cm/year. Sedimentation rates above the 1980 layer of ash deposition from Mt. St. Helens ranged from 0.03 to 2.0 cm/year (Woods, 2000).

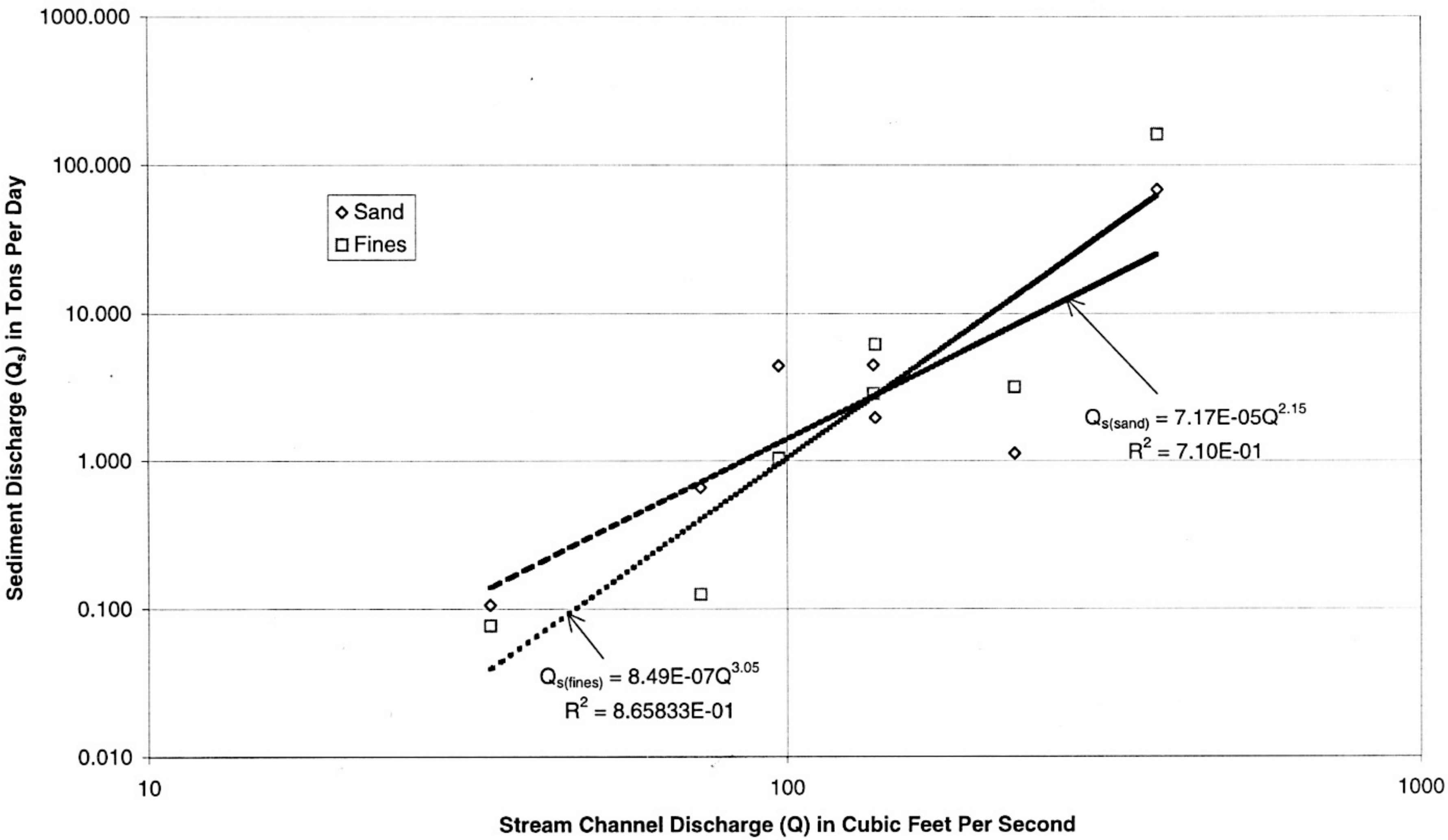
5.4.3.3 Estimation of Benthic Flux

Two general methods were used to estimate metal fluxes across the sediment/water interface at the bottom of Coeur d'Alene Lake: an indirect computational method and direct measurement methods. The indirect computational method assumes molecular diffusive flux is the driving force for transport across the interface.

5.4.3.3.1 Indirect Estimation of Benthic Flux Using Computational Methods. Fluxes of metals across the sediment/water interface may occur as a result of bioturbation, diffusion, and advection. Observations to date indicate that bioturbation is expected to result in a minor contribution to fluxes. (personal communication April 27, 2000; Woods, 2000). Furthermore, water velocities are thought to be low so that advective flux is also assumed minimal. The present understanding is that molecular diffusive flux is the predominant contributor to metal transport across the sediment/water interface. Accordingly, only computed diffusive fluxes were used to estimate meal transport across the sediment/water interface.

As mentioned, molecular diffusive fluxes of metals (e.g., lead, zinc, and cadmium) across the sediment/water interface were calculated. Moreover, the fluxes of additional ions of importance to fate and transport in the lake were computed. For example, the flux of sulfate was calculated to evaluate whether diffusive fluxes of sulfate from the lake to the sediments are sufficient to account for the purported concentrations of metal sulfides residing in the sediments. Furthermore, fluxes of nutrients (e.g., nitrate and phosphate) were computed. Additionally, the flux of oxygen from overlying lake water to the sediments was calculated.

5.4.3.3.2 Direct Estimation of Benthic Flux. Calculations using molecular diffusive fluxes only indirectly calculate metal fluxes. Direct methods of computing fluxes are available and were used. Specifically, the USGS (Kuwabara et al. 2000) used benthic flux chambers (Lander) and core incubations to provide direct computations of benthic flux. Direct measurement methods also implicitly include fluxes from other physical processes (not included in the computational method), such as advection and bioturbation, in addition to diffusive fluxes.



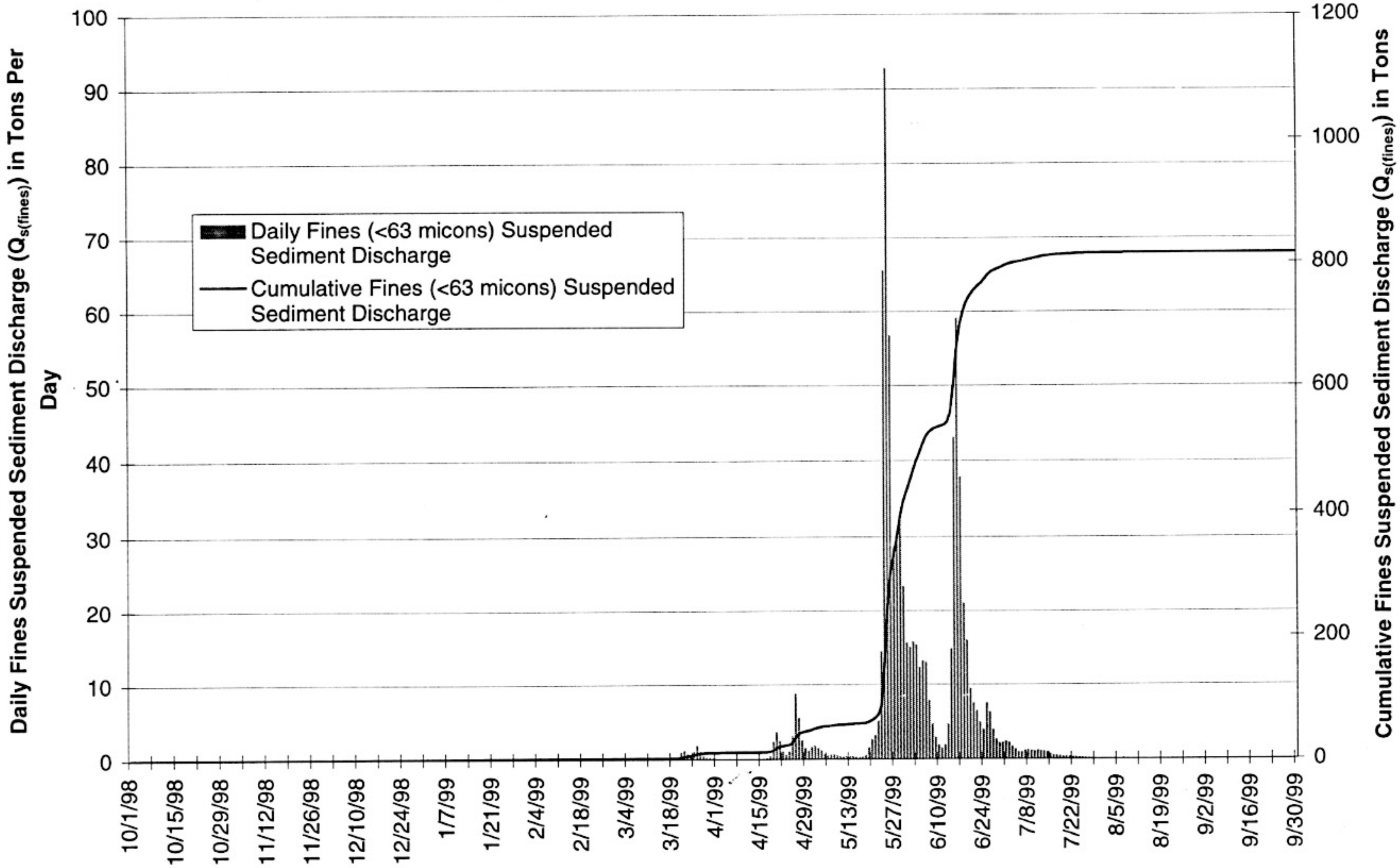
EPA REGION 10

027-RI-CO-102Q
Coeur d'Alene Basin RI/FS

Doc. Control: 4162500.6615.05.a
Generation: 1

RI-535
062000

Figure 5.4-1
Suspended Sediment Rating Curves, Canyon Creek at Wallace, Station 12413125, Suspended Sediment by Sand Break, Water Year 1999



EPA REGION 10

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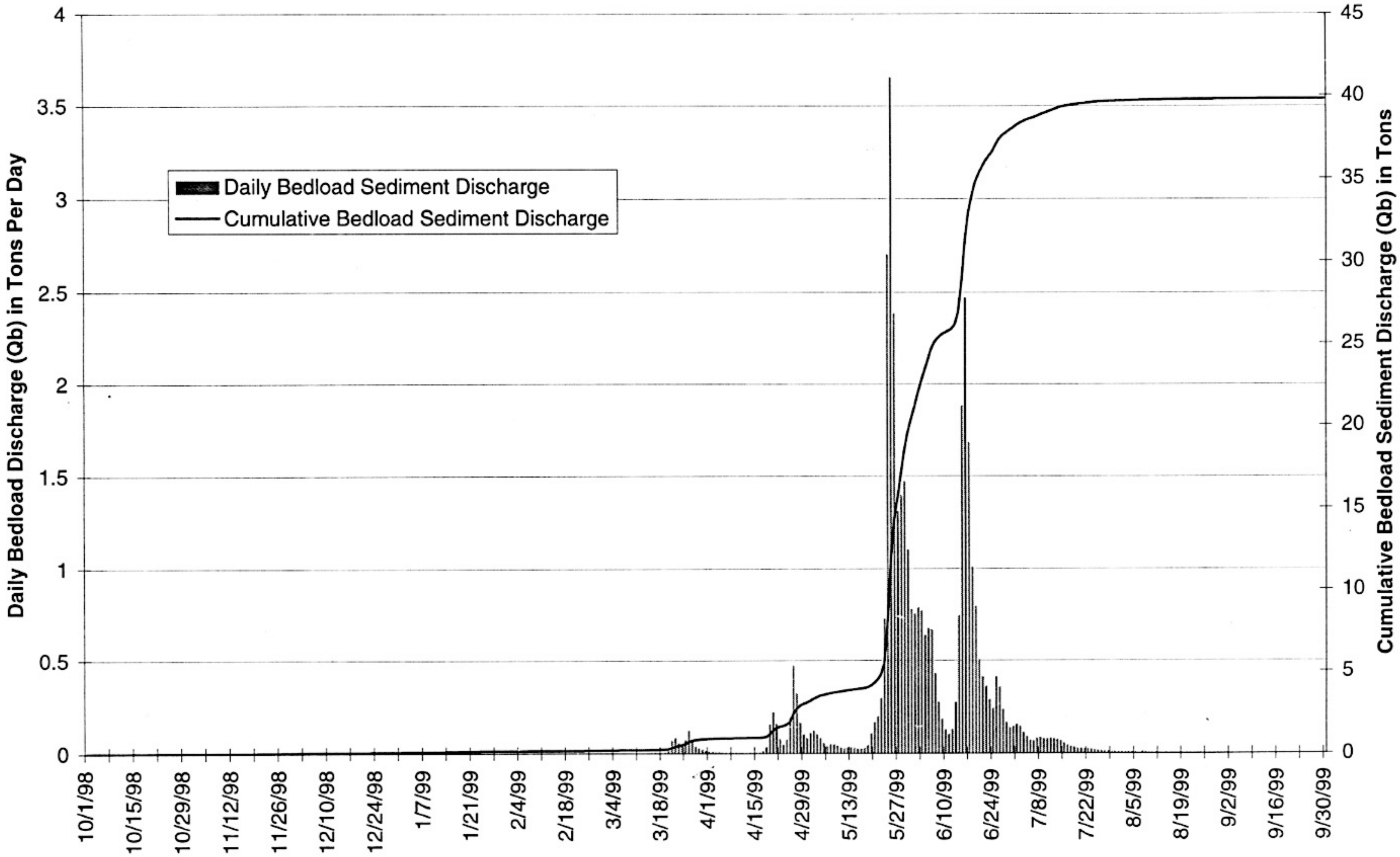
Coeur d'Alene Basin RI/FS

Doc. Control: 4162500.6615.05.a
Generation: 1

RI-536
062000

Figure 5.4-2
Fines Suspended Sediment Discharge, Canyon Creek at Wallace, Station 12413125, Daily and Cumulative Totals, Water Year 1999



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Doc. Control: 4162500.6615.05.a
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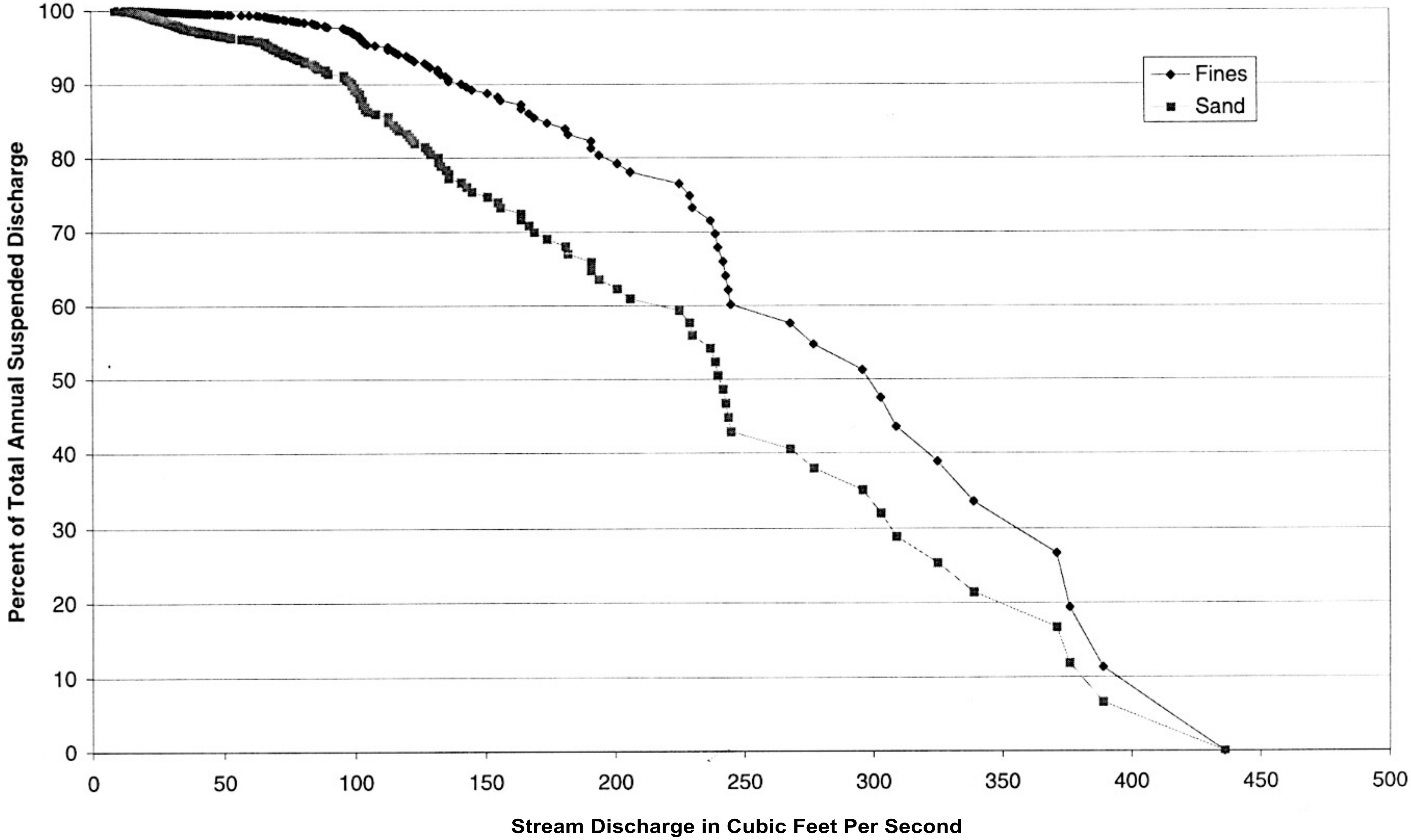
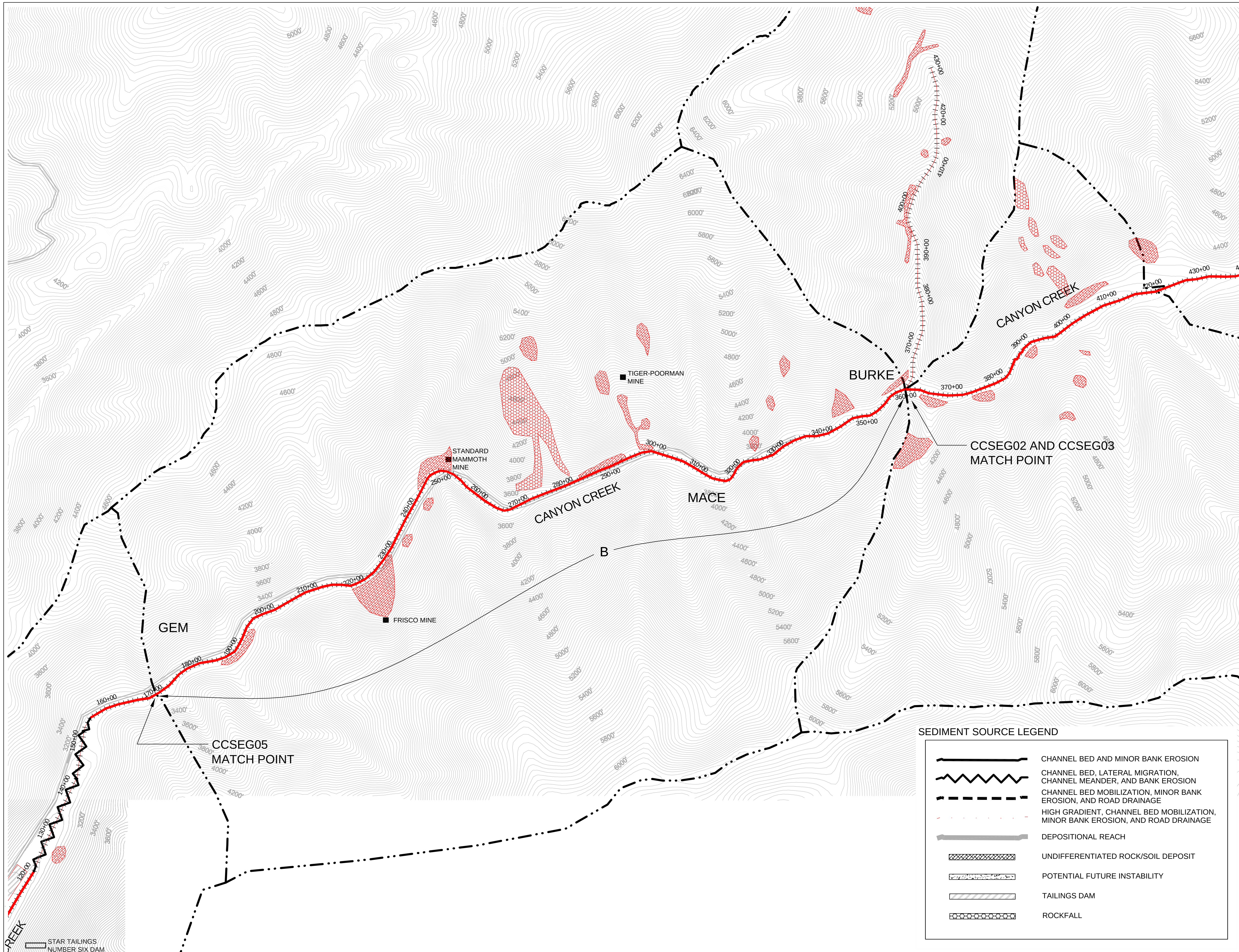
RI-537
062000

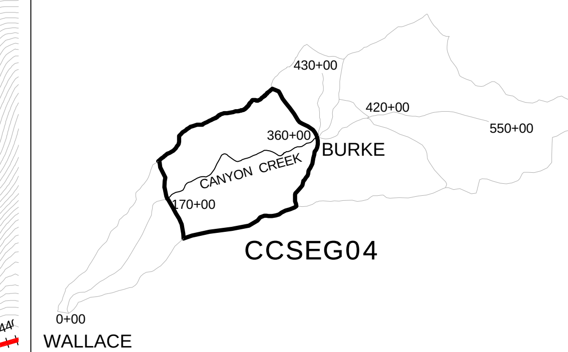
Figure 5.4-3
Bedload Sediment Discharge, Canyon Creek at Wallace, Station 12413125



EPA REGION 10	027-RI-CO-102Q Coeur d'Alene Basin RI/FS	Doc. Control: 4162500.6615.05.a Generation: 1 RI-538 062000	**Figure 5.4-4** **Canyon Creek, Station 12413125, Percent of Annual Suspended Sediment Discharge, Passed at Stream Transport Equal or Greater Than**

Figure 5.4-5
Canyon Creek Segment 04 Site Plan





LEGEND

- BASIN BOUNDARY
- CONTOUR LINE
- CHANNEL CENTERLINE
- INTERSTATE/ROAD/TRAIL
- Aa+ ROSGEN CLASSIFICATION

NOTES:

1. MAP FEATURES AND CONTOURS PRODUCED BY AMERICAN DIGITAL CARTOGRAPHY, COPYRIGHT 1995, AND BASED ON 7.5 MINUTE SERIES MAPS, REVISED 1977, ZONE ID-W.
2. VERTICAL DATUM BASED ON NAD83 IDAHO STATE PLANE COORDINATE SYSTEM.
3. CONTOUR INTERVAL IS 25 FEET.
4. CHANNEL CENTERLINE TAKEN AT APPROXIMATE LOW POINT OF STREAM CHANNEL.
5. SEDIMENT SOURCE LOCATIONS ARE APPROXIMATE AND ARE BASED ON TOPOGRAPHIC MAP AND AERIAL PHOTOGRAPH INTERPRETATION.

N S E W

0 2000 4000
Scale in Feet

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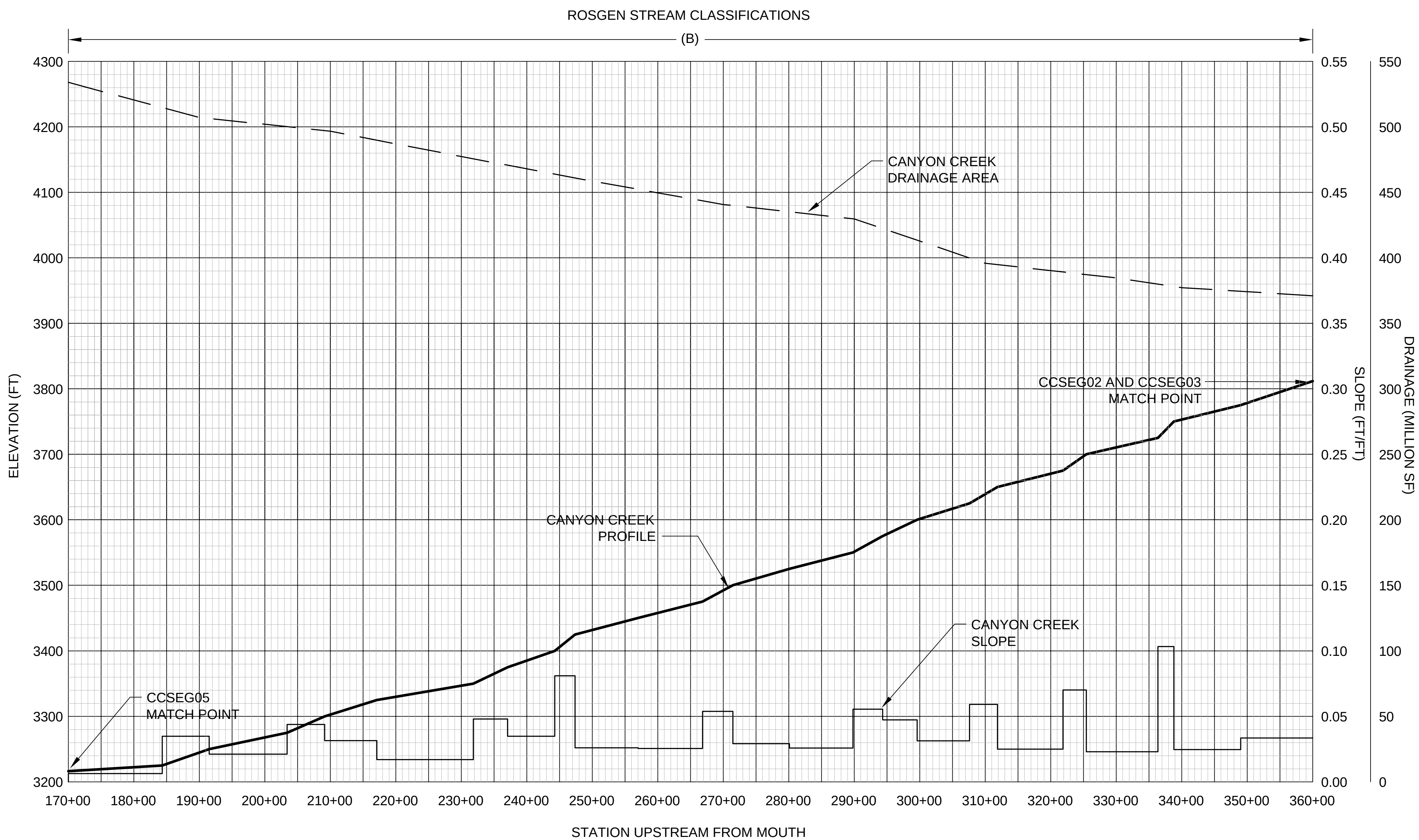
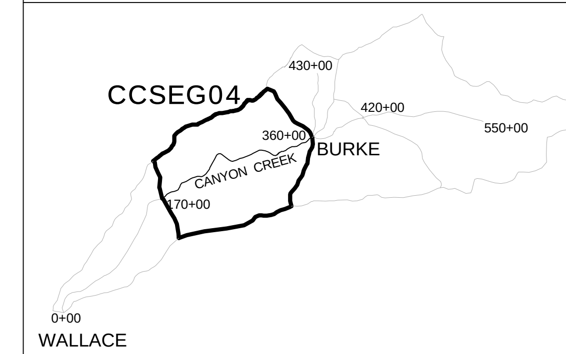
Doc. Control: 4162500.6615.05.a
Generation: 2
N:Coverages/Others/ShannonWilson/CanyonCreek/Canyon_Site2.dwg
Layout: CCSeg04
08/04/01

This map is based on Idaho State Plane Coordinates West Zone, North American Datum 1983.

Date of Plot: October 23, 2000

Figure 5.4-6
Canyon Creek Segment 04





LEGEND

- SEGMENT PROFILE
- SEGMENT SLOPE
- SEGMENT DRAINAGE AREA (SF)

NOTES:

1. CHANNEL PROFILE AND SLOPES ARE APPROXIMATE AND BASED ON MAP PRODUCED BY AMERICAN DIGITAL CARTOGRAPHY, COPYRIGHT 1995, AND BASED ON 7.5 MINUTE SERIES MAPS, REVISED 1977, ZONE ID-W.
2. VERTICAL DATUM BASED ON NAD83 IDAHO STATE PLANE COORDINATE SYSTEM.
3. DRAINAGE AREAS ARE APPROXIMATE AND MAY NOT BE LINEAR AS INDICATED BY PLOT.

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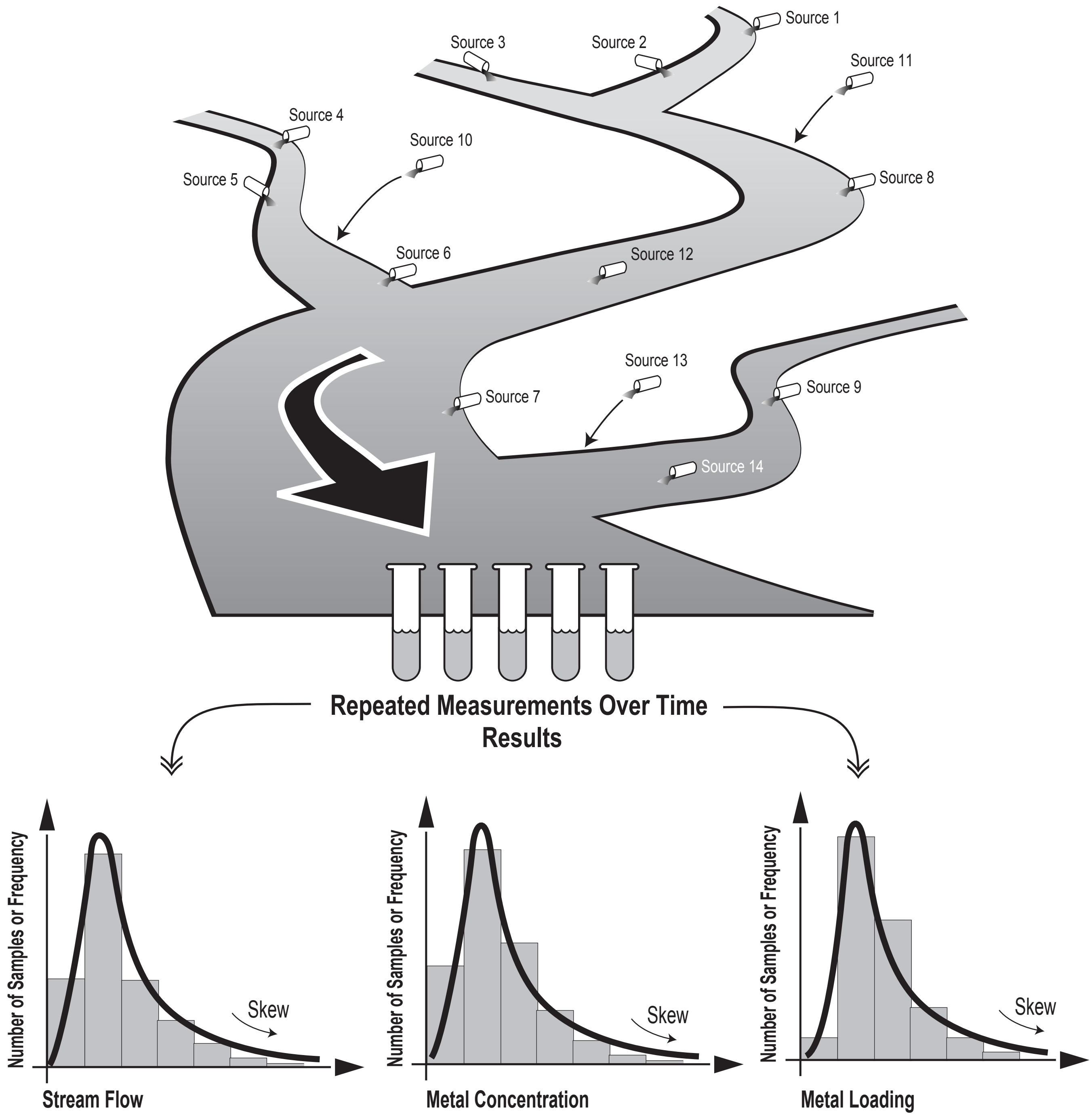
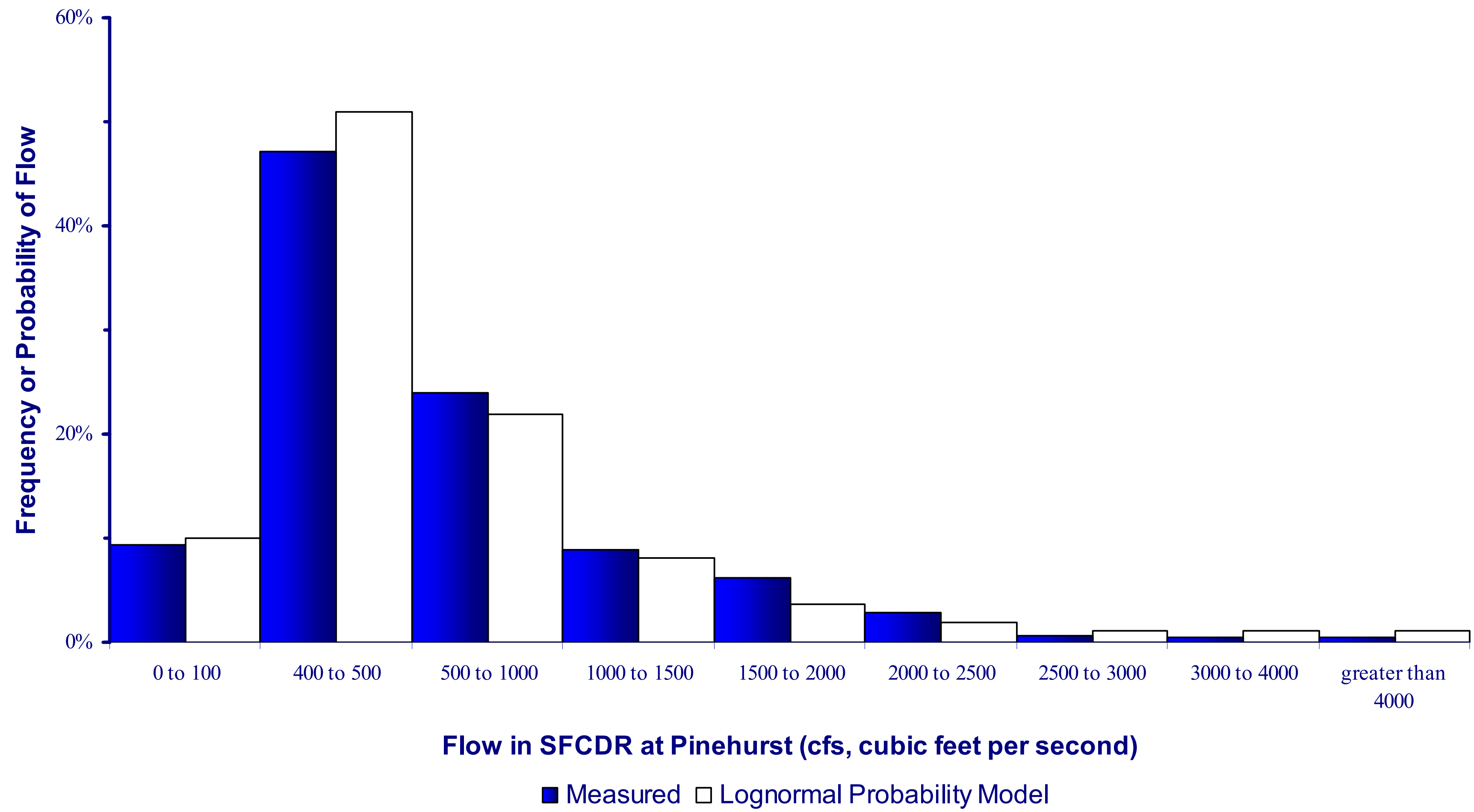
Doc. Control: 4162500.6615.05.a
Generation: 2
N:\Coverages\Others\Shannon &Wilson\Canyon Creek\Canyon_Section1.dwg
Layout: CCSeg04
07/31/01



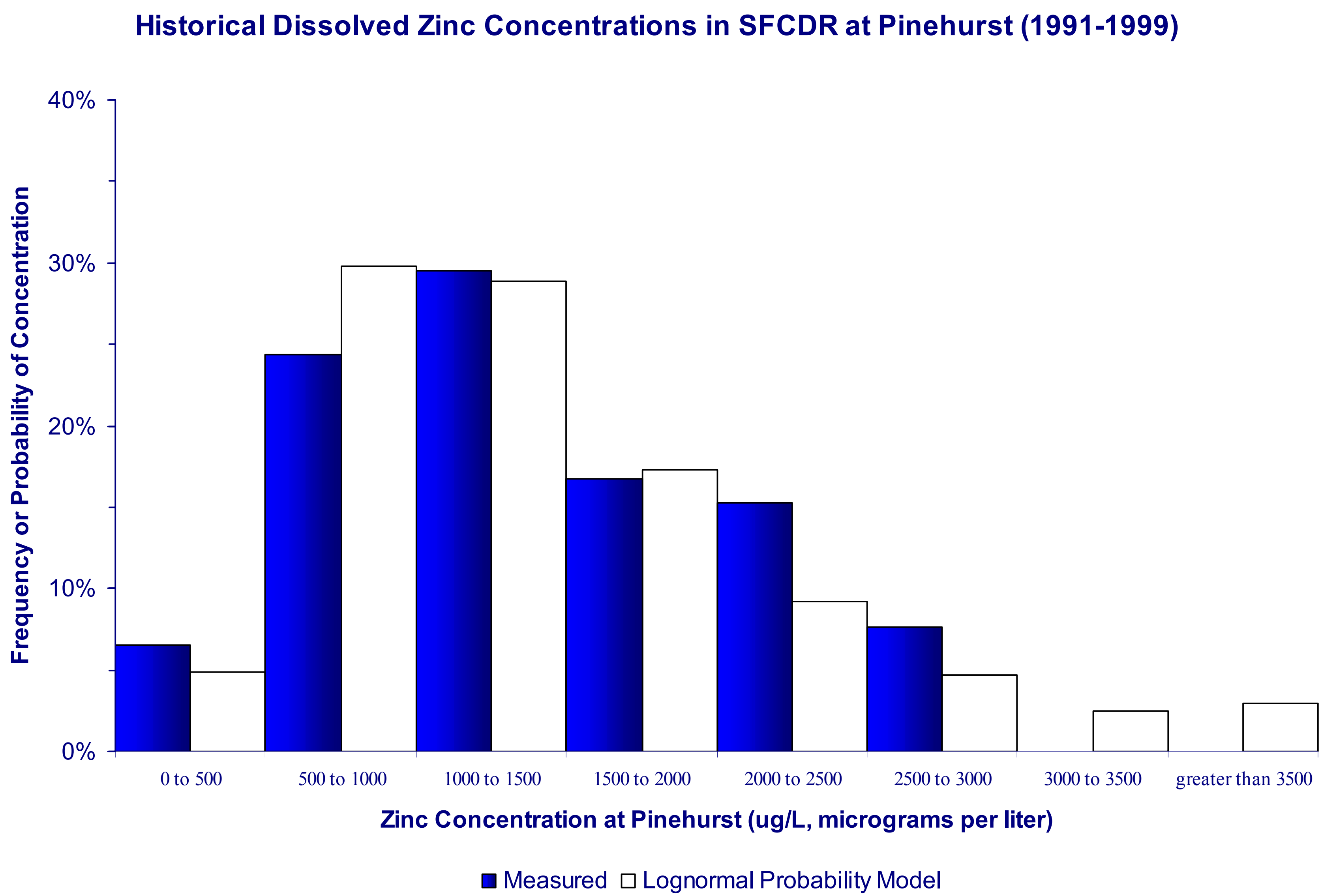
Stream flow, metal concentration, and metal loadings all show lognormal distributions

EPA REGION 10	027-RI-CO-102Q Coeur d'Alene Basin RI/FS RI PEPORT	Doc. Control: 4162500.6615.05.a Generation: 1 RI-3111 051700	**Figure 5.4-7** **Stream Sampling, Lognormal Distributions**

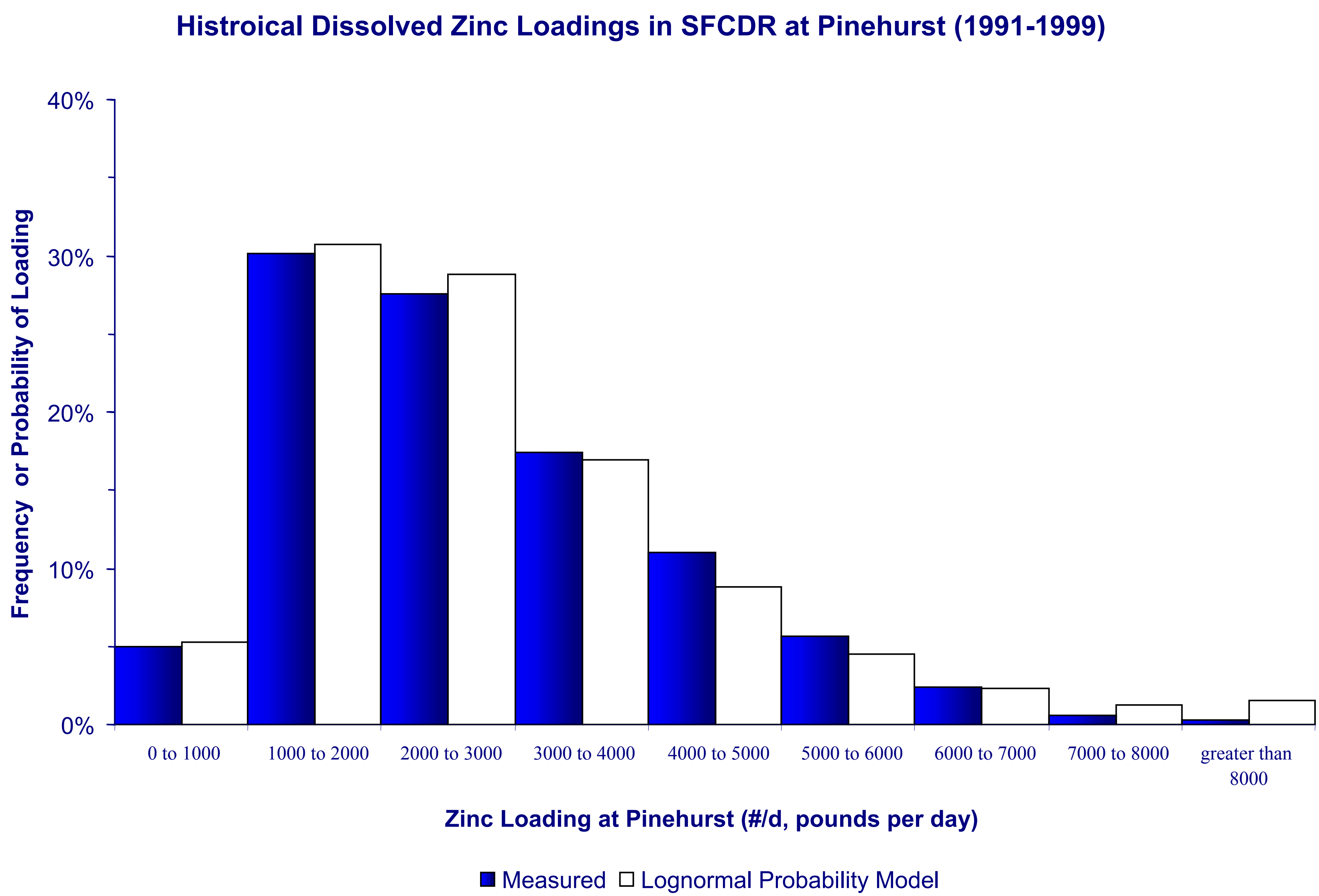
Historical Stream Flow (Discharge) in SFCDR at Pinehurst (1991-1999)



EPA REGION 10	027-RI-CO-102Q Coeur d'Alene Basin RI/FS RI REPORT	Doc Control: 4162500.5907.05.a Generation: 1 Canyon Creek Series 10/16/00	Figure 5.4-8



EPA REGION 10	027-RI-CO-102Q Coeur d'Alene Basin RI/FS RI REPORT	Doc Control: 4162500.5907.05.a Generation: 1 Canyon Creek Series 10/16/00	Figure 5.4-9



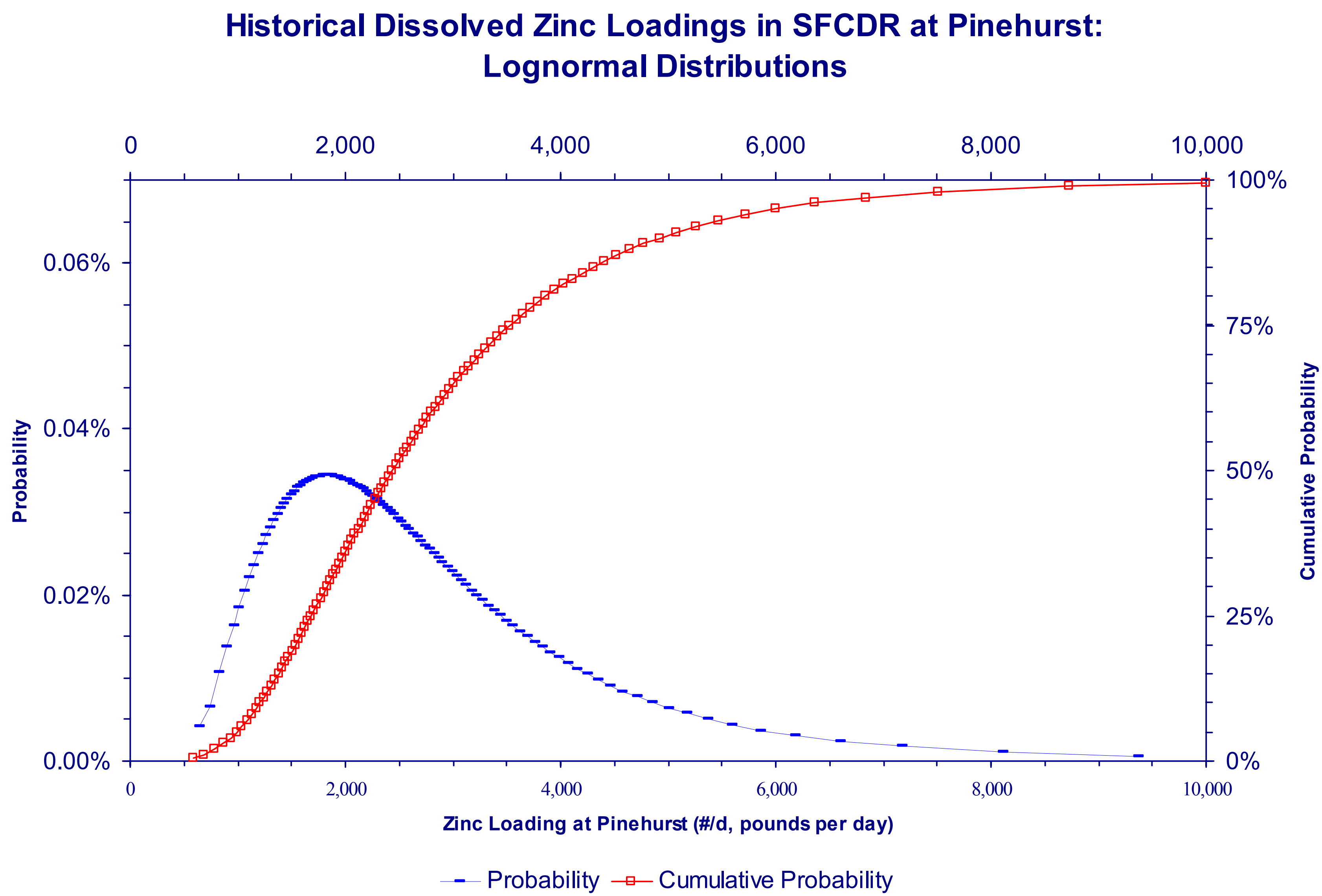
EPA REGION 10

027-RI-CO-102Q
Coeur d'Alene Basin RI/FS
RI REPORT

Doc Control: 4162500.5907.05.a
Generation: 1

Canyon Creek Series
10/16/00

Figure 5.4-10



EPA REGION 10	027-RI-CO-102Q Coeur d'Alene Basin RI/FS RI REPORT	Doc Control: 4162500.5907.05.a Generation: 1 Canyon Creek Series 10/16/00	**Figure 5.4-11**

Table 5.1-1
Chemicals of Potential Concern

Chemical	Human Health COPC			Ecological COPC		
	Soil/Sediment	Groundwater	Surface Water	Soil	Sediment	Surface Water
Antimony	X	X				
Arsenic	X	X	X	X	X	
Cadmium	X	X	X	X	X	X
Copper				X	X	X
Iron	X					
Lead	X	X	X	X	X	X
Manganese	X		X			
Mercury			X		X	
Silver					X	
Zinc	X	X	X	X	X	X

Table 5.1-2
Screening Levels for Groundwater and Surface Water (in μg/L)

	National Ambient Water Quality Criteria (NAWQC)[a]				National Drinking Water Standards[b]				
	Freshwater Aquatic Life Protection		Human Health Protection for Consumption of:						
Chemical	CMC[c]	CCC[c]	Water + Organisms[d]	Organisms Only[d]	MCL	SMCL	U.S. EPA Region IX PRG for Tap Water[e]	Coeur d'Alene River Basin Surface Water Background[f] (Diss.)	Aquatic Plant Chronic Benchmark[g]
Antimony	NA	NA	14	4,300	6	NA	14.6	2.92	NA
Arsenic	340	150	0.018	0.14	50	NA	0.045	0.91	NA
Cadmium	0.62[h]	0.11[h]	5	5	5	NA	18.25	0.38	2
Copper	4.3[h]	3.2[h]	1,300	NA	1,300	1,000	1,356	1.48	1
Iron	NA	1,000	300	NA	NA	300	10,950	46.8	NA
Lead	17[h]	0.66[h]	15	15	15	NA	NA	1.09	500
Manganese	NA	NA	50	100	NA	50	876	20.4	NA
Mercury	1.4	0.77	0.05	0.051	2	NA	10.95	0.66	NA
Silver	0.43[h]	NA	NA	NA	NA	100	182.5	0.14	NA
Zinc	42[h]	43[h]	9,100	69,000	NA	5,000	10,950	24.2	30

Notes:
CMC - Criteria Maximum Concentration
CCC - Criteria Continuous Concentration
MCL - Maximum Contaminant Level
SMCL - Secondary Maximum Contaminant Level
NA - not applicable or available
NC - not calculated
μg/L - microgram per liter

[a] 40 CFR 131.36. National Recommended Water Quality Criteria for Priority Toxic Pollutants. U.S. EPA Office of Water. EPA 822-Z-99-001. April 1999. For cadmium: Updated April 12, 2001. Federal Register Vol. 66, No. 71.
[b] 40 CFR 141 and 143. National Primary and Secondary Drinking Water Regulations. U.S. EPA Office of Water. Office of Groundwater and Drinking Water. http://www.epa.gov/OGWDW/wot/appa.html. October 18, 1999.
[c] Freshwater NAWQC for protection of aquatic life are expressed in terms of the dissolved metal in the water column.
[d] NAWQC for protection of human health are expressed in terms of the total metal in the water column.
[e] U.S. EPA Region IX Preliminary Remediation Goals for Tap Water. http://www.epa.gov/region09/wasate/sfund/prg. February 3, 2000.
[f] Dissolved surface water 95th percentile background concentrations calculated from URS project database. Technical Memorandum. Estimation of Background Concentration in Soils, Sediments, and Surface Waters. Coeur d'Alene Basin RI/FS. URS. May 2001.
[g] Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota: 1996 Revision. U.S. Department of Energy. Office of Environmental Management. ES/ER/TM-96/R2. Value based on total metals concentration.

Table 5.1-2 (Continued)
Screening Levels for Groundwater and Surface Water (in µg/L)

[h] Freshwater NAWQC for cadmium, copper, lead, silver, and zinc are expressed as a function of hardness (mg/L of $CaCO_3$) in the water column. Values above correspond to a hardness value of 30 mg/L, which is representative of hardness values encountered in the Coeur d'Alene River Basin and Coeur d'Alene Lake. The hardness values encountered in the Spokane River Basin show a marked increase between Post Falls and the outlet of Long Lake. NAWQC for each of the three watershed segments in the Spokane River Basin are summarized below:

National Ambient Water Quality Criteria[a] for Spokane River Basin Watershed Segments

Chemical	Spokane River Basin - SpokaneRSeg01		Spokane River Basin - SpokaneRSeg02		Spokane River Basin - SpokaneRSeg03	
	Hardness = 20 mg/L		Hardness = 37 mg/L		Hardness = 59 mg/L	
	CMC	CCC	CMC	CCC	CMC	CCC
Cadmium	0.42	0.08	0.77	0.12	1.2	0.17
Copper	2.9	2.3	5.3	3.8	8.2	5.7
Lead	11	0.42	22	0.84	36	1.4
Silver	0.22	NA	0.62	NA	1.4	NA
Zinc	30	30	50	51	75	76

[a]40 CFR 131.36. National Recommended Water Quality Criteria for Priority Toxic Pollutants. U.S. EPA Office of Water. EPA 822-Z-99-001. April 1999. For cadmium: Updated April 12, 2001. Federal Register Vol. 66, No. 71.

Notes:
CMC - Criteria Maximum Concentration
CCC - Criteria Continuous Concentration
µg/L - microgram per liter
mg/L - milligram per liter

Values were calculated according to the following formulae:

$$\text{CMC (dissolved) in } \mu g/L = \exp\{mA[\ln(\text{hardness})]+bA\}\ (CF)$$
$$\text{CCC (dissolved) in } \mu g/L = \exp\{mC[\ln(\text{hardness})]+bC\}\ (CF)$$

Table 5.1-2 (Continued)
Screening Levels for Groundwater and Surface Water (in μg/L)

Where:

Chemical	m_A	b_A	m_C	b_C	Freshwater Conversion Factors (CF)	
					Acute	Chronic
Cadmium	1.0166	-3.924	0.7409	-4.719	1.136672-[ln(hardness) (0.041838)]	1.101672-[ln(hardness) (0.041838)]
Copper	0.9422	-1.7	0.8545	-1.702	0.96	0.96
Lead	1.273	-1.46	1.273	-4.705	1.46203-[ln(hardness) (0.145712)]	1.46203-[ln(hardness) (0.145712)]
Silver	1.72	-6.52	--	--	0.85	--
Zinc	0.8473	0.884	0.8473	0.884	0.978	0.986

Table 5.1-3
Screening Levels for Soil—Upper Coeur d'Alene River Basin (in mg/kg dry weight)

Chemical	U.S. EPA Region IX PRG for Soil[a]		Upper Coeur d'Alene River Basin– 90th Percentile Background[e]	IEUBK Model Results[b]	Ecological PRGs[c]	Bunker Hill ROD[d]
	Residential	Industrial				
Antimony	31.3	818	5.8	NA	NA	NA
Arsenic	0.39	2.73	22	NA	16.8	NA
Cadmium	37.0	810	2.7	NA	9.8	NA
Copper	2,900	75,900	53	NA	100	NA
Iron	23,500	612,000	65,000	NA	NA	NA
Lead	NA	NA	171	400	2.5	1,000
Manganese	1,760	32,300	3,597	NA	NA	NA
Mercury	23.5	613	0.3	NA	NA	NA
Silver	391	10,200	1.1	NA	NA	NA
Zinc	23,500	612,000	280	NA	27	NA

[a] U.S. EPA Region IX Preliminary Remediation Goals for Residential or Industrial Soil http://www.epa.gov/region09/wasate/sfund/prg. February 3, 2000.
[b] Integrated Exposure Uptake Biokinetic Model for Lead in Children. EPA PB93-9635121.7-15-2.
[c] Final Ecological Risk Assessment. Coeur d'Alene Basin RI/FS. Prepared by CH2M HILL/URS for EPA Region 10. May 18, 2001. Values are the lowest of the NOAEL-based PRG for terrestrial biota (Table ES-3).
[d] Residential soil threshold cleanup level Record of Decision. Bunker Hill Mining and Metallurgical Complex Residential Soils Operable Unit. Shoshone County, Idaho. EPA/ROD/RLO-91/028. August 1991.
[e] Technical Memorandum. Estimation of Background Concentration in Soils, Sediments, and Surface Waters. Coeur d'Alene Basin RI/FS. URS. May 2001.

Notes:
IEUBK - Integrated Exposure Uptake Biokinetic Model
NA - not applicable or available
mg/kg - milligram per kilogram

Table 5.1-4
Screening Levels for Freshwater Sediment—Upper Coeur d'Alene River Basin (in mg/kg dry weight)

Chemical	Sediment Quality Benchmarks[a]				Upper Coeur d'Alene River Basin–90th Percentile Background[f]	Bunker Hill ROD[g]	Ecological PRGs[h]
	Lowest Threshold Effects Level[b]	Threshold Effects Level[c]	Probable Effects Level[d]	Upper Effects Level[e]			
Antimony	NA	NA	NA	3	3.30	NA	NA
Arsenic	10.8	5.9	17	17	13.6	NA	54
Cadmium	0.583	0.596	3.53	3	1.56	NA	11.7
Copper	28	35.7	197	86	32.3	NA	1606
Iron	188,400	NA	NA	40,000	26,000	NA	NA
Lead	37	35	91.3	127	51.5	1,000	3.65
Manganese	630	NA	NA	1,100	1,210	NA	NA
Mercury	NA	0.174	0.486	0.56	0.179	NA	0.2
Silver	NA	NA	NA	4.5	1.1	NA	NA
Zinc	98	123.1	315	520	200	NA	5.3

[a] Values as presented in National Oceanographic and Atmospheric Administration Screening Quick Reference Tables, NOAA HAZMAT Report 99-1, Seattle, WA. M. F. Buchman, 1999.
[b] Calculation and Evaluation of Sediment Effect Concentrations for the Amphipod Hyalella azteca and the Midge Chironomus riparius. EPA 905-R96-008. U.S. EPA 1996. U.S. EPA Region V Great Lakes National Program Office. Value represents the lowest Hyalella azteca Threshold Effects Level in the Assessment and Remediation of Contaminated Sediments (ARCS) Database.
[c] Canadian sediment quality guidelines for the protection of aquatic life: Summary Tables. In: Canadian Environmental Quality Guidelines. (Environment Canada 1994). The threshold effects level is calculated from the geometric mean of the 15th percentile concentration from the effect data set and the 50th percentile concentration from the no effect data set. Final Ecological Risk Assessment. Coeur d'Alene Basin RI/FS. Prepared by CH2M HILL/URS for EPA Region 10. May 18, 2001. Values are the lowest of the NOAEL-based PRG.
[d] Canadian sediment quality guidelines for the protection of aquatic life: Summary Tables. In: Canadian Environmental Quality Guidelines (Environment Canada 1994). The probable effects level is calculated from the geometric mean of the 50th percentile concentration of the effect data set and the 85th percentile concentration of the no effect data set.
[e] Values as presented in National Oceanographic and Atmospheric Administration Screening Quick Reference Tables, NOAA HAZMAT Report 99-1, Seattle, WA. M. F. Buchman, 1999. Values generated from numerous reference documents.
[f] Technical Memorandum. Estimation of Background Concentration in Soils, Sediments, and Surface Waters. Coeur d'Alene Basin RI/FS. URS. May 2001.

Table 5.1-4 (Continued)
Screening Levels for Freshwater Sediment—Upper Coeur d'Alene River Basin
(in mg/kg dry weight)

[g] Residential soil threshold cleanup level. Record of Decision. Bunker Hill Mining and Metallurgical Complex Residential Soils Operable Unit. Shoshone County, Idaho. EPA/ROD/RLO-91/028. August 1991.

[h] Final Ecological Risk Assessment. Coeur d'Alene Basin RI/FS. Prepared by CH2M HILL/URS for EPA Region 10. May 18, 2001. Values are the lowest of the NOAEL-based PRG for aquatic birds and mammals (Table ES-4).

Note:
NA - not applicable or available
mg/kg - milligram per kilogram

Table 5.1-5
Screening Levels for Soil—Lower Coeur d'Alene River Basin (in mg/kg dry weight)

Chemical	U.S. EPA Region IX PRG for Soil[a]		Lower Coeur d'Alene River Basin–90th Percentile Background[e]	IEUBK Model Results[b]	Ecological PRGs[c]	Bunker Hill ROD[d]
	Residential	Industrial				
Antimony	31.3	818	1.63	NA	NA	NA
Arsenic	0.39	2.73	12.6	NA	16.8	NA
Cadmium	37.0	810	0.678	NA	9.8	NA
Copper	2,900	75,900	25.2	NA	100	NA
Iron	23,500	612,000	27,600	NA	NA	NA
Lead	NA	NA	47.3	400	2.5	1,000
Manganese	1,760	32,300	325	NA	NA	NA
Mercury	23.5	613	0.3[f]	NA	NA	NA
Silver	391	10,200	0.324	NA	NA	NA
Zinc	23,500	612,000	97.1	NA	27	NA

[a] U.S. EPA Region IX Preliminary Remediation Goals for Residential or Industrial Soil http://www.epa.gov/region09/wasate/sfund/prg. February 3, 2000.
[b] Integrated Exposure Uptake Biokinetic Model for Lead in Children. EPA PB93-9635121.7-15-2.
[c] Final Ecological Risk Assessment. Coeur d'Alene Basin RI/FS. Prepared by CH2M HILL/URS for EPA Region 10. May 18, 2001. Values are the lowest of the NOAEL-based PRG for birds and mammals (Appendix J).
[d] Residential soil threshold cleanup level Record of Decision. Bunker Hill Mining and Metallurgical Complex Residential Soils Operable Unit. Shoshone County, Idaho. EPA/ROD/RLO-91/028. August 1991.
[e] Technical Memorandum. Estimation of Background Concentration in Soils, Sediments, and Surface Waters. Coeur d'Alene Basin RI/FS. URS. May 2001.
[f] 90th percentile background concentration for Upper Coeur d'Alene River Basin soils.

Notes:
IEUBK - Integrated Exposure Uptake Biokinetic Model
NA - not applicable or available
mg/kg - milligram per kilogram

Table 5.1-6
Screening Levels for Freshwater Sediment—Lower Coeur d'Alene River Basin (in mg/kg dry weight)

Chemical	Sediment Quality Benchmarks[a]				Lower Coeur d'Alene River Basin– 90th Percentile Background[f]	Bunker Hill ROD[g]	Ecological PRGs[h]
	Lowest Threshold Effects Level[b]	Threshold Effects Level[c]	Probable Effects Level[d]	Upper Effects Level[e]			
Antimony	NA	NA	NA	3	1.63	NA	NA
Arsenic	10.8	5.9	17	17	12.6	NA	54
Cadmium	0.583	0.596	3.53	3	0.678	NA	11.7
Copper	28	35.7	197	86	25.2	NA	1606
Iron	188,400	NA	NA	40,000	27,600	NA	NA
Lead	37	35	91.3	127	47.3	1,000	3.65
Manganese	630	NA	NA	1,100	325	NA	NA
Mercury	NA	0.174	0.486	0.56	0.179[h]	NA	0.2
Silver	NA	NA	NA	4.5	0.324	NA	NA
Zinc	98	123.1	315	520	97.1	NA	5.3

[a] Values as presented in National Oceanographic and Atmospheric Administration Screening Quick Reference Tables, NOAA HAZMAT Report 99-1, Seattle, WA. M. F. Buchman, 1999.
[b] Calculation and Evaluation of Sediment Effect Concentrations for the Amphipod Hyalella azteca and the Midge Chironomus riparius. EPA 905-R96-008. U.S. EPA 1996. U.S. EPA Region V Great Lakes National Program Office. Value represents the lowest Hyalella azteca Threshold Effects Level in the Assessment and Remediation of Contaminated Sediments (ARCS) Database.
[c] Canadian sediment quality guidelines for the protection of aquatic life: Summary Tables. In: Canadian Environmental Quality Guidelines. (Environment Canada 1994). The threshold effects level is calculated from the geometric mean of the 15th percentile concentration from the effect data set and the 50th percentile concentration from the no effect data set. Final Ecological Risk Assessment. Coeur d'Alene Basin RI/FS. Prepared by CH2M HILL/URS for EPA Region 10. May 18, 2001. Values are the lowest of the NOAEL-based PRG.
[d] Canadian sediment quality guidelines for the protection of aquatic life: Summary Tables. In: Canadian Environmental Quality Guidelines (Environment Canada 1994). The probable effects level is calculated from the geometric mean of the 50th percentile concentration of the effect data set and the 85th percentile concentration of the no effect data set.
[e] Values as presented in National Oceanographic and Atmospheric Administration Screening Quick Reference Tables, NOAA HAZMAT Report 99-1, Seattle, WA. M. F. Buchman, 1999. Values generated from numerous reference documents.
[f] Technical Memorandum. Estimation of Background Concentration in Soils, Sediments, and Surface Waters. Coeur d'Alene Basin RI/FS. URS. May 2001.

Table 5.1-6 (Continued)
Screening Levels for Freshwater Sediment—Lower Coeur d'Alene River Basin
(in mg/kg dry weight)

[g] Residential soil threshold cleanup level. Record of Decision. Bunker Hill Mining and Metallurgical Complex Residential Soils Operable Unit. Shoshone County, Idaho. EPA/ROD/RLO-91/028. August 1991.
[h] Final Ecological Risk Assessment. Coeur d'Alene Basin RI/FS. Prepared by CH2M HILL/URS for EPA Region 10. May 18, 2001. Values are the lowest of the NOAEL-based PRG for aquatic birds and mammals (Table ES-4).
[i] 90th percentile background concentration for Upper Coeur d'Alene Basin sediments.

Note:
NA - not applicable or available.
mg/kg - milligram per kilogram

Table 5.1-7
Screening Levels for Soil—Spokane River Basin (in mg/kg dry weight)

Chemical	U.S. EPA Region IX PRG for Soil[a]		Spokane River Basin–90th Percentile Background[e]	IEUBK Model Results[b]	Ecological PRGs[c]	Bunker Hill ROD[d]	MTCA[f]	
	Residential	Industrial					Residential	Industrial
Antimony	31.3	818	1.63	NA	NA	NA	32	1,400
Arsenic	0.39	2.73	9.34	NA	16.8	NA	1.67	219
Cadmium	37.0	810	0.72	NA	9.8	NA	80	3,500
Copper	2,900	75,900	23.9	NA	100	NA	2,960	13,000
Iron	23,500	612,000	25,000	NA	NA	NA	NA	NA
Lead	NA	NA	14.9	400	2.5	1,000	250	1,000
Manganese	1,760	32,300	663	NA	NA	NA	11,200	490,000
Mercury	23.5	613	0.032	NA	NA	NA	24	1,050
Silver	391	10,200	0.324	NA	NA	NA	400	17,500
Zinc	23,500	612,000	66.4	NA	27	NA	24,000	105,000

[a] U.S. EPA Region IX Preliminary Remediation Goals for Residential or Industrial Soil http://www.epa.gov/region09/wasate/sfund/prg. February 3, 2000.
[b] Integrated Exposure Uptake Biokinetic Model for Lead in Children. EPA PB93-9635121.7-15-2.
[c] Final Ecological Risk Assessment. Coeur d'Alene Basin RI/FS. Prepared by CH2M HILL/URS for EPA Region 10. May 18, 2001. Values are the lowest of the NOAEL-Based PRG for birds and mammals (Appendix J).
[d] Residential soil threshold cleanup level Record of Decision. Bunker Hill Mining and Metallurgical Complex Residential Soils Operable Unit. Shoshone County, Idaho. EPA/ROD/RLO-91/028. August 1991.
[e] Technical Memorandum. Estimation of Background Concentration in Soils, Sediments, and Surface Waters. Coeur d'Alene Basin RI/FS. URS. May 2001.
[f] Model Toxics Control Act

Notes:
IEUBK - Integrated Exposure Uptake Biokinetic Model
NA - not applicable or available
mg/kg - milligram per kilogram

Table 5.1-8
Screening Levels for Freshwater Sediment—Spokane River Basin (in mg/kg dry weight)

Chemical	Sediment Quality Benchmarks[a]				Spokane River Basin–90th Percentile Background[f]	Bunker Hill ROD[g]	Ecological PRGs[h]
	Lowest Threshold Effects Level[b]	Threshold Effects Level[c]	Probable Effects Level[d]	Upper Effects Level[e]			
Antimony	NA	NA	NA	3	1.63	NA	NA
Arsenic	10.8	5.9	17	17	9.34	NA	54
Cadmium	0.583	0.596	3.53	3	0.72	NA	11.7
Copper	28	35.7	197	86	23.9	NA	1606
Iron	188,400	NA	NA	40,000	25,000	NA	NA
Lead	37	35	91.3	127	14.9	1,000	3.65
Manganese	630	NA	NA	1,100	663	NA	NA
Mercury	NA	0.174	0.486	0.56	0.032	NA	0.2
Silver	NA	NA	NA	4.5	0.324	NA	NA
Zinc	98	123.1	315	520	66.4	NA	5.3

[a] Values as presented in National Oceanographic and Atmospheric Administration Screening Quick Reference Tables, NOAA HAZMAT Report 99-1, Seattle, WA. M. F. Buchman, 1999.

[b] Calculation and Evaluation of Sediment Effect Concentrations for the Amphipod Hyalella azteca and the Midge Chironomus riparius. EPA 905-R96-008. U.S. EPA 1996. U.S. EPA Region V Great Lakes National Program Office. Value represents the lowest Hyalella azteca Threshold Effects Level in the Assessment and Remediation of Contaminated Sediments (ARCS) Database.

[c] Canadian sediment quality guidelines for the protection of aquatic life: Summary Tables. In: Canadian Environmental Quality Guidelines. (Environment Canada 1994). The threshold effects level is calculated from the geometric mean of the 15th percentile concentration from the effect data set and the 50th percentile concentration from the no effect data set.

[d] Canadian sediment quality guidelines for the protection of aquatic life: Summary Tables. In: Canadian Environmental Quality Guidelines (Environment Canada 1994). The probable effects level is calculated from the geometric mean of the 50th percentile concentration of the effect data set and the 85th percentile concentration of the no effect data set.

[e] Values as presented in National Oceanographic and Atmospheric Administration Screening Quick Reference Tables, NOAA HAZMAT Report 99-1, Seattle, WA. M. F. Buchman, 1999. Values generated from numerous reference documents.

[f] Technical Memorandum. Estimation of Background Concentration in Soils, Sediments, and Surface Waters. Coeur d'Alene Basin RI/FS. URS. May 2001.

[g] Residential soil threshold cleanup level. Record of Decision. Bunker Hill Mining and Metallurgical Complex Residential Soils Operable Unit. Shoshone County, Idaho. EPA/ROD/RLO-91/028. August 1991.

Table 5.1-8 (Continued)
Screening Levels for Freshwater Sediment—Spokane River Basin (in mg/kg dry weight)

[h] Final Ecological Risk Assessment. Coeur d'Alene Basin RI/FS. Prepared by CH2M HILL/URS for EPA Region 10. May 18, 2001. Values are the lowest of the NOAEL-based PRG for aquatic birds and mammals (Table ES-4).

Note:
NA - not applicable or available
mg/kg - milligram per kilogram

Table 5.1-9
Selected Screening Levels for Groundwater and Surface Water—Coeur d'Alene River Basin and Coeur d'Alene Lake

Chemical	Surface Water Total (µg/L)	Surface Water Dissolved (µg/L)	Groundwater Total (µg/L)	Groundwater Dissolved (µg/L)
Antimony	6[a]	2.92[b]	6[a]	2.92[b]
Arsenic	50[a]	150[c,d]	50[a]	150[c,d]
Cadmium	2[e,f]	0.38[b]	2[e,f]	0.38[b]
Copper	1[e,f]	3.2[c,d]	1[e,f]	3.2[c,d]
Iron	300[a]	1,000[c,d]	300[a]	1,000[c,d]
Lead	15[a]	1.09[b]	15[a]	1.09[b]
Manganese	50[a]	20.4[b]	50[a]	20.4[b]
Mercury	2[a]	0.77[c,d]	2[a]	0.77[c,d]
Silver	100[a]	0.43[c,d]	100[a]	0.43[c,d]
Zinc	30[e,f]	42[c,d]	30[e,f]	42[c,d]

[a] 40 CFR 141 and 143. National Primary and Secondary Drinking Water Regulations. U.S. EPA Office of Water. Office of Groundwater and Drinking Water. http://www.epa.gov/OGWDW/wot/appa.html. October 18, 1999.
[b] Dissolved surface water 95th percentile background concentrations calculated from URS project database.
[c] Freshwater NAWQC for protection of aquatic life are expressed in terms of the dissolved metal in the water column.
[d] Freshwater NAWQC for cadmium, copper, lead, silver, and zinc are expressed as a function of hardness (mg/L of CaCO3) in the water column. Values above correspond to a hardness value of 30 mg/L.
[e] Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota: 1996 Revision. U.S. Department of Energy. Office of Environmental Management. ES/ER/TM-96/R2. Value based on total metals concentration.
[f] value based on protection of aquatic plants.

Notes:
µg/L - microgram per liter
mg/kg - milligram per kilogram

Table 5.1-10
Selected Screening Levels for Surface Water—Spokane River Basin

Chemical	SpokaneRSeg01		SpokaneRSeg02		SpokaneRSeg03	
	Surface Water Total (µg/L)	Surface Water Dissolved (µg/L)	Surface Water Total (µg/L)	Surface Water Dissolved (µg/L)	Surface Water Total (µg/L)	Surface Water Dissolved (µg/L)
Antimony	6[a]	2.92[b]	6[a]	2.92[b]	6[a]	2.92[b]
Arsenic	50[a]	150[c]	50[a]	150[c]	50[a]	150[c]
Cadmium	2[e,f]	0.38[b]	2[e,f]	0.38[b]	2[e,f]	0.38[b]
Copper	1[e,f]	2.3[c,d]	1[e,f]	3.8[c,d]	1[e,f]	5.7[c,d]
Iron	300[a]	1,000[c]	300[a]	1,000[c]	300[a]	1,000[c]
Lead	15[a]	1.09[b]	15[a]	1.09[b]	15[a]	1.4[c,d]
Manganese	50[a]	20.4[b]	50[a]	20.4[b]	50[a]	20.4[b]
Mercury	2[a]	0.77[c]	2[a]	0.77[c]	2[a]	0.77[c]
Silver	100[a]	0.22[c,d]	100[a]	0.62[c,d]	100[a]	1.4[c,d]
Zinc	30[e,f]	30[c,d]	30[e,f]	50[c,d]	30[e,f]	75[c,d]

[a] 40 CFR 141 and 143. National Primary and Secondary Drinking Water Regulations. U.S. EPA Office of Water. Office of Groundwater and Drinking Water. http://www.epa.gov/OGWDW/wot/appa.html. October 18, 1999.
[b] Dissolved surface water 95th percentile background concentrations calculated from URS project database. Technical Memorandum. Estimation of Background Concentration in Soils, Sediments, and Surface Waters. Coeur d'Alene Basin RI/FS. URS. May 2001.
[c] Freshwater NAWQC for protection of aquatic life are expressed in terms of the dissolved metal in the water column.
[d] Freshwater NAWQC for cadmium, copper, lead, silver, and zinc are expressed as a function of hardness (mg/L of CaCO3) in the water column.
[e] Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota: 1996 Revision. U.S. Department of Energy. Office of Environmental Management. ES/ER/TM-96/R2. Value based on total metals concentration.
[f] value based on protection of aquatic plants.

Note:
µg/L - microgram per liter

Table 5.1-11
Selected Screening Levels—Soil and Sediment

Chemical	Upper Coeur d'Alene River Basin		Lower Coeur d'Alene River Basin		Spokane River Basin	
	Soil (mg/kg)	Sediment (mg/kg)	Soil (mg/kg)	Sediment (mg/kg)	Soil (mg/kg)	Sediment (mg/kg)
Antimony	31.3[a]	3.30[b]	31.3[a]	3[c]	31.3[a]	3[c]
Arsenic	22[b]	13.6[b]	12.6[b]	12.6[b]	9.34[b]	9.34[b]
Cadmium	9.8[d]	1.56[b]	9.8[d]	0.678[b]	9.8[d]	0.72[b]
Copper	100[d]	32.3[b]	100[d]	28[c]	100[d]	28[c]
Iron	65,000[b]	40,000[c]	27,600[b]	40,000[c]	25,000[b]	40,000[c]
Lead	171[b]	51.5[b]	47.3[b]	47.3[b]	14.9[b]	14.9[b]
Manganese	3,597[b]	1,210[b]	1,760[a]	630[c]	1,760[a]	663[b]
Mercury	23.5[a]	0.179[b]	23.5[a]	0.179[b]	23.5[a]	0.174[c]
Silver	391[a]	4.5[c]	391[a]	4.5[c]	391[a]	4.5[c]
Zinc	280[b]	200[b]	97.1[b]	97.1[b]	66.4[b]	66.4[b]

[a] U.S. EPA Region IX Preliminary Remediation Goals for Residential or Industrial Soil http://www.epa.gov/region09/wasate/sfund/prg. February 3, 2000.
[b] Technical Memorandum. Estimation of Background Concentration in Soils, Sediments, and Surface Waters. Coeur d'Alene Basin RI/FS. URS. May 2001.
[c] Values as presented in National Oceanographic and Atmospheric Administration Screening Quick Reference Tables, NOAA HAZMAT Report 99-1, Seattle, WA. M. F. Buchman, 1999. Values generated from numerous reference documents.
[d] Final Ecological Risk Assessment. Coeur d'Alene Basin RI/FS. Prepared by CH2M HILL/URS for EPA Region 10. May 18, 2001. Values are the lowest of the NOAEL-based PRG for terrestrial biota (Table ES-3).

Note:
mg/kg - milligram per kilogram

Table 5.2.1-1
Summary Statistics for Soil Background Metals Concentrations (mg/kg) in the Upper Basin (CSM Units 1 and 2)

Metal	25th Percentile	50th Percentile	75th Percentile	90th Percentile
Antimony	0.8	1.1	2.9	5.8
Arsenic [a]	-	-	10	22
Cadmium	0.5	0.8	1.3	2.7
Copper	21	28	37	53
Iron	27,000	36,000	49,000	65,000
Lead	28	43	75	171
Manganese	777	1,333	2,242	3,597
Mercury	0.05	0.1	0.2	0.3
Silver	0.4	0.6	0.7	1.1
Zinc	61	95	161	280

[a] Gott and Cathrall (1980) did not develop a 25th or 50th percentile concentration for arsenic.

Notes:
All values presented as originally reported.
mg/kg - milligram per kilogram
Source: Gott and Cathrall (1980)

Table 5.2.1-2
Summary Statistics for Estimated Sediment Background Metals Concentrations (mg/kg) in the Upper Basin (CSM Units 1 and 2)

Metal	5th Percentile	25th Percentile	50th Percentile	75th Percentile	90th Percentile	95th Percentile	Geometric Mean
Antimony	0.597	1.05	1.56	2.31	3.30	4.08	2.82
Arsenic	1.34	2.89	4.92	8.40	13.6	18.1	4.92
Cadmium	0.043	0.142	0.324	0.742	1.56	2.44	0.431
Copper	6.71	11.3	16.2	23.3	32.3	39.2	16.2
Iron	6,850	10,700	14,500	19,700	26,000	30,700	14,500
Lead	10.3	17.5	25.4	36.9	51.5	63.0	25.4
Manganese	171	327	514	808	1,210	1,550	685
Mercury	0.001	0.004	0.016	0.057	0.179	0.354	0.056
Silver [a]	-	0.4	0.6	0.7	1.1	-	-
Zinc	16.0	37.0	66.3	119	200	274	66.3

[a] Percentile ranges for silver could not be developed due to the high number of non-detects in the background data set. Therefore, the values for silver in Upper Basin soils were selected.

Notes:
All values rounded to three significant figures.
mg/kg - milligram per kilogram
Source: URSG and CH2M HILL (2000)

Table 5.2.1-3
Summary Statistics for Estimated Sediment Background Metals Concentrations (mg/kg) in the Lower Basin (CSM Units 3 and 4)

Metal	5th Percentile	25th Percentile	50th Percentile	75th Percentile	90th Percentile	95th Percentile	Geometric Mean
Antimony	0.685	0.912	1.11	1.36	1.63	1.81	0.652
Arsenic	2.78	4.58	6.48	9.18	12.6	15.1	6.34
Cadmium	0.036	0.095	0.187	0.369	0.678	0.976	0.233
Copper	9.34	13.0	16.3	20.5	25.2	28.5	16.3
Iron	9,910	14,000	17,600	22,300	27,600	31,400	17,600
Lead	12.3	19.3	26.3	35.8	47.3	56.0	26.3
Manganese	48.6	91.2	141	219	325	411	141
Mercury [a]	0.001	0.004	0.016	0.057	0.179	0.354	0.056
Silver	0.221	0.251	0.274	0.299	0.324	0.339	0.280
Zinc	31.0	45.2	58.9	76.6	97.1	112	58.9

[a] Percentile ranges for mercury could not be developed due to the high number of non-detects in the data set. Therefore, the values for mercury in Upper Basin sediments were selected, recognizing that they are biased high.

Notes:
All values rounded to three significant figures.
mg/kg - milligram per kilogram

Source: URSG and CH2M HILL (2000)

Table 5.2.1-4
Summary Statistics for Soil and Sediment Background Metals Concentrations (mg/kg) in the Spokane River Basin (CSM Unit 5)

Metal	5th Percentile	25th Percentile	50th Percentile	75th Percentile	90th Percentile	95th Percentile	Mean [a]
Antimony [b]	0.685	0.912	1.11	1.36	1.63	1.31	0.652
Arsenic	1.66	2.95	4.39	6.53	9.34	11.6	4.39
Cadmium	0.149	0.251	0.361	0.519	0.720	0.876	0.361
Copper	5.18	9.94	13.4	18.2	23.9	28.1	14.4
Iron	12,200	15,500	18,300	21,600	25,000	27,400	18,300
Lead	7.46	9.39	11.0	12.9	14.9	16.2	11.0
Manganese	340	424	495	577	663	721	495
Mercury	0.003	0.007	0.012	0.020	0.032	0.041	0.012
Silver [b]	0.221	0.251	0.274	0.299	0.324	0.339	0.280
Zinc	36.1	44.2	50.8	58.5	66.4	71.6	50.8

[a] All means are geometric means except copper. The arithmetic mean was calculated for copper because it has a normal data distribution. The 95 percent UCLs are calculated on the geometric means for all COPCs except copper (95 percent MCL on the arithmetic mean).

[b] Ecology soil samples were not analyzed for antimony or silver (WDOE 1994). Therefore, the Lower Basin sediment values were selected, recognizing that they are biased high.

Notes:
All values rounded to three significant figures.
mg/kg - milligram per kilogram

Source: WDOE (1994)

Table 5.2.2-1
Median and Percentile Ranges for Background Dissolved Surface Water Metals Concentrations in the South Fork Coeur d'Alene River Basin

Sub-Area	Statistical Analysis	Hardness*	Metal (µg/L)									
		µg/L	Antimony	Arsenic	Cadmium	Copper	Iron	Lead	Manganese	Mercury	Silver	Zinc
Upper South Fork Coeur d'Alene River	Median	26,950	0.25	0.53	0.06	0.63	7.50	0.17	1.50	0.10	0.06	6.13
	25th percentile	8,680	0.18	0.35	0.04	0.63	7.50	0.11	1.50	0.10	0.06	5.00
	75th percentile	47,632	0.25	0.61	0.10	0.88	7.50	0.29	1.75	0.10	0.08	10.70
	95th percentile	115,014	0.27	0.69	0.20	1.50	49.10	1.11	22.17	0.10	0.14	24.37
Page-Galena Mineral Belt	Median	39,972	0.69	0.61	0.16	0.88	12.00	0.40	2.07	0.10	0.06	7.49
	25th percentile	32,994	0.25	0.35	0.10	0.64	7.92	0.23	1.42	0.10	0.06	5.45
	75th percentile	58,108	0.99	0.75	0.19	1.00	19.14	0.73	2.68	0.10	0.08	19.11
	95th percentile	77,443	3.19	0.94	0.40	1.28	26.33	0.98	4.00	0.73	0.08	22.96
Pine Creek Drainage	Median	6,401	0.21	0.20	0.10	0.43	12.92	0.21	1.33	0.10	0.04	3.13
	25th percentile	6,328	0.15	0.11	0.03	0.22	7.10	0.19	1.11	0.10	0.02	2.49
	75th percentile	9,044	0.32	0.35	0.18	0.69	21.03	0.27	1.75	0.10	0.06	5.13
	95th percentile	15,301	0.48	0.51	0.20	0.84	25.86	0.41	2.35	0.10	0.08	8.79
Entire South Fork Coeur d'Alene River Basin	Median	26,950	0.25	0.53	0.08	0.63	12.00	0.21	1.50	0.10	0.06	6.13
	25th percentile	7,504	0.16	0.23	0.04	0.53	7.30	0.15	1.26	0.10	0.04	3.74
	75th percentile	52,870	0.65	0.74	0.18	0.75	20.08	0.51	2.22	0.10	0.08	14.90
	95th percentile	111,257	2.92	0.91	0.38	1.48	46.82	1.09	20.35	0.66	0.14	24.23
National Ambient Water Quality Criteria (NAWQC) Criteria Continuous Concentrations (CCC)		NA	NA	150	0.11[a]	3.2[a]	1,000	0.66[a]	NA	0.77	0.43[b]	43[a]

Table 5.2.2-1 (Continued)
Median and Percentile Ranges for Background Dissolved Surface Water Metals Concentrations in the South Fork Coeur d'Alene River Basin

[a] Freshwater AWQC for cadmium, lead, silver, and zinc are expressed as a function of hardness (mg/L of $CaCO^3$) in the water column. Values shown were calculated using a hardness value of 30 mg/L.
[b]NAWQC value for silver is the Criteria Maximum Concentration.

Notes:
NA - Not applicable or available
µg/L - microgram per liter
mg/L - milligram per liter

Table 5.3-1
Summary of Mass Loading Data Sources

Source	Period	Frequency	Stations
MFG (1991, 1992)	May-91	High flow synoptic	57 in SFCDR watershed
	Oct-91	Low flow synoptic	70 in SFCDR watershed
IDEA (1998, 1999)	WY94-95	Trend sampling. Generally monthly. Some bimonthly during high flow	26 in SFCDR watershed, 3 on main stem CDR
	WY96 to March 99		13 to 17 in SFCDR watershed, 3 on main stem CDR
	WY94 to present	Effectiveness monitoring. Typically during high and low flow periods.	Up to 15 on Ninemile Cr, Canyon Cr, Moon Cr, and Bunker Hill Superfund Site.
USGS (Woods and Beckwith 1997; Beckwith et al. 1997; Balistrieri 1998; Woods 2000a, b, c; USGS 2000)	WY 91 and 92	33 to 52 sampling events	CDR and St. Joe River near CDA Lake; Spokane River at Post Falls
	WY 93 and 94	Monthly; weekly during spring runoff	5 on SFCDR; 1 on NFCDR
	1996-97 adit sampling	Generally twice	19 adits within South Fork watershed
	1996-97 river sampling	5 events	2 on SFCDR, 1 on NFCDR
	WY99	Monthly	24 (increased to 30 after 4/99), basinwide
	May 1999	High flow synoptic	42, basinwide
	1999	3 low flow events	Woodland Park, Osburn Flats, Smelterville Flats
URS (2000)	Nov-97	Low flow synoptic	153 in SFCDR and NFCDR basins
	May-98	High flow synoptic	203 in SFCDR and NFCDR basins
	Nov-98	Low flow synoptic	45 on Canyon Cr., Ninemile Cr., McFarren Gulch, Pine Cr., SFCDR
Golder (1998)	1996	Low flow synoptic	9 locations on SFCDR between Wallace and Big Cr.
	Aug and Sept 98	2 events (Phase 1 and 2)	SFCDR and main stem CDR, Pine Creek confluence to Cataldo. Phase 1: 28 stations, Phase 2: 7 stations

Table 5.3-1 (Continued)
Summary of Mass Loading Data Sources

Source	Period	Frequency	Stations
USBM (McNavy et al 1995; Paulson 1996; SAIC 1993)	1993	Rising and falling limb, peak, rain-on-snow, and flow-flow events	18 locations in Pine Cr. watershed
	Spring 1993	One time	7 locations in Pine Cr. watershed
	April through Dec 1993	5 events	2 to 7 locations in Moon Cr. watershed
USFS (Kauffman 1999)	July/August 1997	One time	18 adits in SFCDR watershed
BLM (CCJM 1998)	June/August 1993 July 1994	One time	4 adits in Pine Cr. watershed
	Quarterly Aug-97 to Nov-98	3 times	1 adit in Pine Cr. watershed
Hecla (Ridolfi 1999)	1991	One time	11 adits in SFCDR watershed
Asarco (Ridolfi 1999)	July 1997 to July 1998	Generally monthly	Gem No. 3 adit
Ecology & Environment (1995)	October 1994	One time	66 on SFCDR, Pine Cr., and Canyon Cr.

Table 5.3-2
Summary of Mass Loading Sampling Locations

URS Location ID	Type	URS			MFG			IDEQ		USGS WY99		
		Nov-97	May-98	Nov-98	Station ID	May-91	Oct-91	Station ID	WY96-98	Station ID	Monthly	High-flow
BC260	RV	x	x		BC-1	x	x			12413185		x
BV1	RV		x									
BV3	RV		x									
BV4	RV		x									
BV5	RV		x									
BV6	RV		x									
BV7	RV		x									
BV8	RV		x									
BV9	RV		x									
BV10	RV		x									
BV11	RV		x									
BV12	RV		x									
BV50	RV	x	x							12411950		x
CC1	RV				CC-110	x	x					
CC2	RV				CC-100	x	x					
CC15	RV				CC-40							
CC17	RV			x	CC-25		x					
CC19	SP				SPTP-1	x	x					
CC20	SP				WPSEEP-1		x					
CC23	RV				CC-10A/10B	x	x					
CC272	RV	x										
CC273	RV	x	x									
CC274	RV	x										
CC276	RV	x		x	CC-90	x	x			12413118	x	x
CC277	RV	x	x	x	CC-80	x	x					
CC278	RV	x	x		CC-70	x	x					
CC279	RV	x		x	CC-61	x	x					
CC280	RV	x		x	CC-60	x	x					
CC281	RV	x	x		CC-50	x	x					
CC282	RV	x	x	x				CC-2.5	x	12413120		x
CC283	RV	x	x									
CC284	RV	x			CC-30	x	x	CC-2	thru Apr 96			
CC285	RV	x	x		CC-20	x	x	CC-1.5	x	12413123	x	x
CC286	RV	x	x	x	CC-16		x					
CC287	RV	x	x		CC-12		x	CC-1	x			
CC288	RV	x	x	x						12413125	x	x
CC289	RV		x									
CC290	RV		x									

Table 5.3-2 (Continued)
Summary of Mass Loading Sampling Locations

URS Location ID	Type	URS			MFG			IDEQ		USGS WY99		
		Nov-97	May-98	Nov-98	Station ID	May-91	Oct-91	Station ID	WY96-98	Station ID	Monthly	High-flow
CC291	RV		x					CC-3	Jan. 98 on			
CC354	AD		x									
CC355	AD		x		GEM-1	x	x					
CC357	SP		x									
CC371	AD	x										
CC372	AD	x			TAM-1	x	x					
CC373	AD	x										
CC388	AD	x	x		HERC-1	x	x					
CC392	RV		x	x	GORG-1	x	x					
CC410	RV			x								
CC411	RV			x								
CC420	RV			x								
CC421	RV			x								
CC425	RV			x								
CC436	RV			x								
CC438	RV			x								
CC439	RV			x								
CC443	RV			x								
CC444	RV			x								
CC454	RV			x								
CC455	RV			x								
CC457	RV			x								
CC482	RV			x								
CC484	RV			x								
CC485	RV			x								
CC486	RV			x								
LC50	RV							Cataldo	x	12413500	x	x
LC55	RV							Rose Lake	x	12413810	x	x
LC60	RV							Harrison	x	12413860	x	x
MC262	RV	x	x		MC-1	x	x	MC-1	x	12413190	x	x
NF2	RV		x									
NF13	RV		x							12411000	x	x
NF19	RV		x									
NF20	RV		x									
NF21	RV		x									
NF22	RV		x									
NF37	RV		x									
NF38	RV		x									

Table 5.3-2 (Continued)
Summary of Mass Loading Sampling Locations

URS Location ID	Type	URS			MFG			IDEQ		USGS WY99		
		Nov-97	May-98	Nov-98	Station ID	May-91	Oct-91	Station ID	WY96-98	Station ID	Monthly	High-flow
NF46	RV		x									
NF47	RV		x									
NF50	RV									12413000	x	x
NM8	RV				ENM-10	x	x					
NM13	RV				NM-16		x					
NM100	RV									124131267		x
NM289	RV	x	x		ENM-60	x	x					
NM290	RV		x									
NM291	RV	x	x	x	ENM-50	x	x	ENM-5	5 times			
NM292	RV	x	x	x								
NM293	RV	x	x		ENM-40	x	x	ENM-4	5 times			
NM294	RV	x	x	x								
NM295	RV	x	x	x	ENM-30	x	x	ENM-3	5 times			
NM296	RV	x	x	x	ENM-20	x	x	ENM-2	x			
NM297	RV	x	x	x	ENM-15		x					
NM298	RV	x	x							12413127	x	x
NM299	RV	x	x		NM-40	x	x					
NM300	RV	x	x							12413126		x
NM301	RV	x	x		NM-30	x	x					
NM302	RV	x	x	x								
NM303	RV	x	x		NM-20	x	x					
NM304	RV	x	x									
NM305	RV	x	x		NM-10	x	x	NM-1	x	12413130	x	x
NM359	AD		x									
NM360	AD	x	x									
NM361	AD	x	x									
NM362	SP	x	x		IC-1	x	x					
NM363	SP		x									
NM364	AD		x									
NM365	AD											
NM366	AD	x	x									
NM367	AD	x										
NM368	SP	x	x									
NM369	AD	x										
NM370	AD	x										
NM374	SP		x									
NM412	RV			x								
NM435	RV			x								

Table 5.3-2 (Continued)
Summary of Mass Loading Sampling Locations

URS Location ID	Type	URS			MFG			IDEQ		USGS WY99		
		Nov-97	May-98	Nov-98	Station ID	May-91	Oct-91	Station ID	WY96-98	Station ID	Monthly	High-flow
NM436	RV											
NM440	RV			x								
NM443	RV			x								
NM448	RV			x								
NM458	RV			x								
PC100	RV			x								
PC305	RV							PC-1	to Nov 96			
PC306	RV	x	x							12413360		x
PC307	RV	x	x									
PC308	RV	x	x									
PC309	RV	x	x									
PC310	RV	x										
PC311	RV	x	x							12413440		x
PC312	RV	x	x									
PC313	RV		x	x				PC-2	Dec 97-Jun 98			
PC314	RV	x	x									
PC315	RV	x	x							12413460		x
PC322	RV		x									
PC323	RV		x									
PC324	RV		x									
PC325	RV		x									
PC326	RV		x									
PC327	RV		x									
PC329	SP	x	x									
PC330	AD	x	x									
PC331	AD	x	x									
PC332	AD	x	x									
PC333	AD	x	x									
PC334	AD	x										
PC335	AD	x	x									
PC336	AD	x	x									
PC337	AD	x	x									
PC338	RV		x									
PC339	RV		x					PC-3	Jul 98 on	12413445	x	x
PC340	AD	x	x									
PC341	AD	x	x									
PC343	AD	x	x									

Table 5.3-2 (Continued)
Summary of Mass Loading Sampling Locations

URS Location ID	Type	URS Nov-97	URS May-98	URS Nov-98	MFG Station ID	MFG May-91	MFG Oct-91	IDEQ Station ID	IDEQ WY96-98	USGS WY99 Station ID	USGS WY99 Monthly	USGS WY99 High-flow
PC344	AD	x										
PC348	AD	x	x									
PC351	AD	x										
PC352	SP	x										
PC375	SP		x									
PC400	AD		x									
PR14	RV		x							12411935	x	x
PR16	RV		x									
PR17	RV		x									
PR18	RV		x									
PR23	RV		x									
PR24	RV		x									
PR25	RV		x									
PR26	RV		x									
PR27	RV		x									
PR28	RV		x									
PR29	RV		x									
PR30	RV		x									
PR31	RV		x									
PR32	RV		x									
PR33	RV		x									
PR34	RV		x									
PR35	RV		x									
PR36	RV		x									
PR41	RV		x									
PR42	RV		x									
PR43	RV		x									
PR44	RV		x									
PR45	RV		x									
PR48	RV		x									
PR49	RV		x									
SF2	RV											
SF10	RV				SF-128		x					
SF11	RV				SF-130	x	x					
SF12	RV				SF-135		x	SF-7	x			
SF15	RV				SF-140	x	x					
SF16	RV				SF-145		x					
SF20	RV				RG-1	x	x					

Table 5.3-2 (Continued)
Summary of Mass Loading Sampling Locations

URS Location ID	Type	URS			MFG			IDEQ		USGS WY99		
		Nov-97	May-98	Nov-98	Station ID	May-91	Oct-91	Station ID	WY96-98	Station ID	Monthly	High-flow
SF22	RV				SF-165		x					
SF23	RV				SG-1	x	x					
SF31	RV				SF-187		x					
SF33	OF				SUN-1	x	x					
SF201	RV	x	x									
SF202	RV	x	x							12413025		x
SF204	RV	x	x									
SF205	RV	x	x		SF-1	x	x			12413030		x
SF206	RV	x	x									
SF207	RV	x	x									
SF208	RV	x	x		SF-100	x	x			12413040	x	x
SF209	RV	x	x									
SF210	RV	x	x									
SF211	RV	x	x									
SF212	RV	x	x									
SF213	RV	x	x									
SF214	RV	x	x									
SF215	RV	x	x		SF-105	x	x					
SF216	RV	x										
SF218	RV	x	x									
SF219	RV	x	x									
SF220	RV	x	x		SF-110	x	x			12413103		x
SF221	RV	x	x									
SF222	RV		x									
SF223	RV	x	x									
SF224	RV	x	x									
SF225	RV	x	x									
SF226	RV	x	x									
SF227	RV	x	x		SF-120	x	x			12413104		x
SF228	RV	x	x		SF-125	x	x		x			
SF229	RV	x	x									
SF230	RV	x	x									
SF231	RV	x										
SF232	RV	x										
SF233	RV	x	x							12413131		x
SF234	RV	x	x		PC-1	x	x			12413140	x	x
SF235	RV	x	x									
SF236	RV	x	x		DC-1	x	x					

Table 5.3-2 (Continued)
Summary of Mass Loading Sampling Locations

URS Location ID	Type	URS			MFG			IDEQ		USGS WY99		
		Nov-97	May-98	Nov-98	Station ID	May-91	Oct-91	Station ID	WY96-98	Station ID	Monthly	High-flow
SF237	RV	x										
SF238	RV	x	x		LC-1	x	x			12413151		x
SF239	RV	x	x		SF-150	x	x			12413150	x	x
SF240	RV	x	x									
SF241	RV	x			SF-154		x					
SF242	RV	x	x									
SF243	RV	x										
SF244	RV	x	x									
SF245	RV	x	x		NG-1	x	x					
SF246	RV		x									
SF247	RV	x										
SF248	RV	x	x		TWO-1	x	x			12413168		x
SF249	RV	x	x		SF-170	x	x			12413169	x(added)	x
SF250	RV		x		MCFG-1	x						
SF251	RV	x	x									
SF252	RV	x	x		TG-1	x	x			12413174		x
SF253	RV	x	x		SF-180	x	x			12413175		x
SF254	RV	x	x		SF-183	x	x					
SF255	RV	x	x									
SF256	RV	x	x									
SF257	RV	x	x									
SF258	RV	x										
SF259	RV	x	x		SF-190	x	x			12413179		x
SF261	RV	x	x									
SF263	RV	x			SF-195		x					
SF264	RV	x	x		SF-197		x					
SF265	RV	x	x									
SF266	RV	x	x		MG-1	x				12413204		x
SF267	RV	x	x							12413209		x
SF268	RV	x	x		SF-2	x	x	SF-3	x	12413210	x	x
SF269	RV	x										
SF270	RV	x	x					SF-2	x	12413300		x
SF271	RV	x	x		SF-8	x	x	SF-1	x	12413470	x	x
SF272	RV		x		SF-160	x	x					
SF273	RV		x									
SF274	RV		x									
SF275	RV		x									
SF316	RV		x									

Table 5.3-2 (Continued)
Summary of Mass Loading Sampling Locations

URS Location ID	Type	URS			MFG			IDEQ		USGS WY99		
		Nov-97	May-98	Nov-98	Station ID	May-91	Oct-91	Station ID	WY96-98	Station ID	Monthly	High-flow
SF317	RV		x									
SF318	RV		x									
SF319	RV		x									
SF320	RV		x									
SF321	RV		x									
SF328	SP	x	x									
SF338	AD		x									
SF339	AD		x									
SF345	AD		x									
SF346	AD		x									
SF347	AD		x									
SF349	AD		x									
SF350	AD											
SF382	AD	x	x									
SF383	AD	x										
SF384	AD	x										
SF385	AD	x										
SF386	AD	x										
SF389	AD	x										
SF390	AD	x										
SF392	AD	x										
SF393	AD	x	x									
SF394	AD	x	x		MORN-1	x	x					
SF395	AD	x	x									
SF396	AD	x	x									
SF426	RV			x								
SF427	RV			x								
SF429	RV			x								
SF430	RV			x								
SF431	RV			x								
SF655	RV									12413250		x
SF660	RV									12413290	x	x
SJ4	RV	x										
SJ50	RV									12414500	x	
SJ55	RV									12414900	x	
SR5	RV	x										
SR6	RV	x										
SR50	RV									12419000	x	

Table 5.3-2 (Continued)
Summary of Mass Loading Sampling Locations

URS Location ID	Type	URS			MFG			IDEQ		USGS WY99		
		Nov-97	May-98	Nov-98	Station ID	May-91	Oct-91	Station ID	WY96-98	Station ID	Monthly	High-flow
SR75	RV									12422500	x	
SR80	RV									12424000	x(added Apr. 1999)	
SR85	RV									12433000	x	
SR55	RV									12419500	x(added Apr. 1999)	
SR60	RV									12420500	x(added Apr. 1999)	
SR65	RV									12420800	x(added Apr. 1999)	
SR70	RV									12422000	x(added Apr. 1999)	

Notes:
AD - adit sample
OF - outfall sample
RV - river or stream sample
SP - seep or spring sample

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